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ABSTRACT

This science guide is developed to assist North Dakota school and administrative personnel in developing coordinated programs in elementary science suitable to their own needs and resources. The guide offers sample objectives to be used in developing a list of behavioral objectives; outlines for developing a scope for the program; offers assistance in arranging a science sequence; develops units of study; offers a variety of practices for evaluation; and provides information, activities, and resources for enriching the elementary school science program. Appendices include: publishers of science texts for elementary schools, supply houses for science equipment and supplies, sources of educational media, professional references in elementary school science education, English metric conversion table, temperature conversion table, relative humidity, and suggested science sequences. (BB)

Science Guide

Grades 1-6 North Dakota Schools

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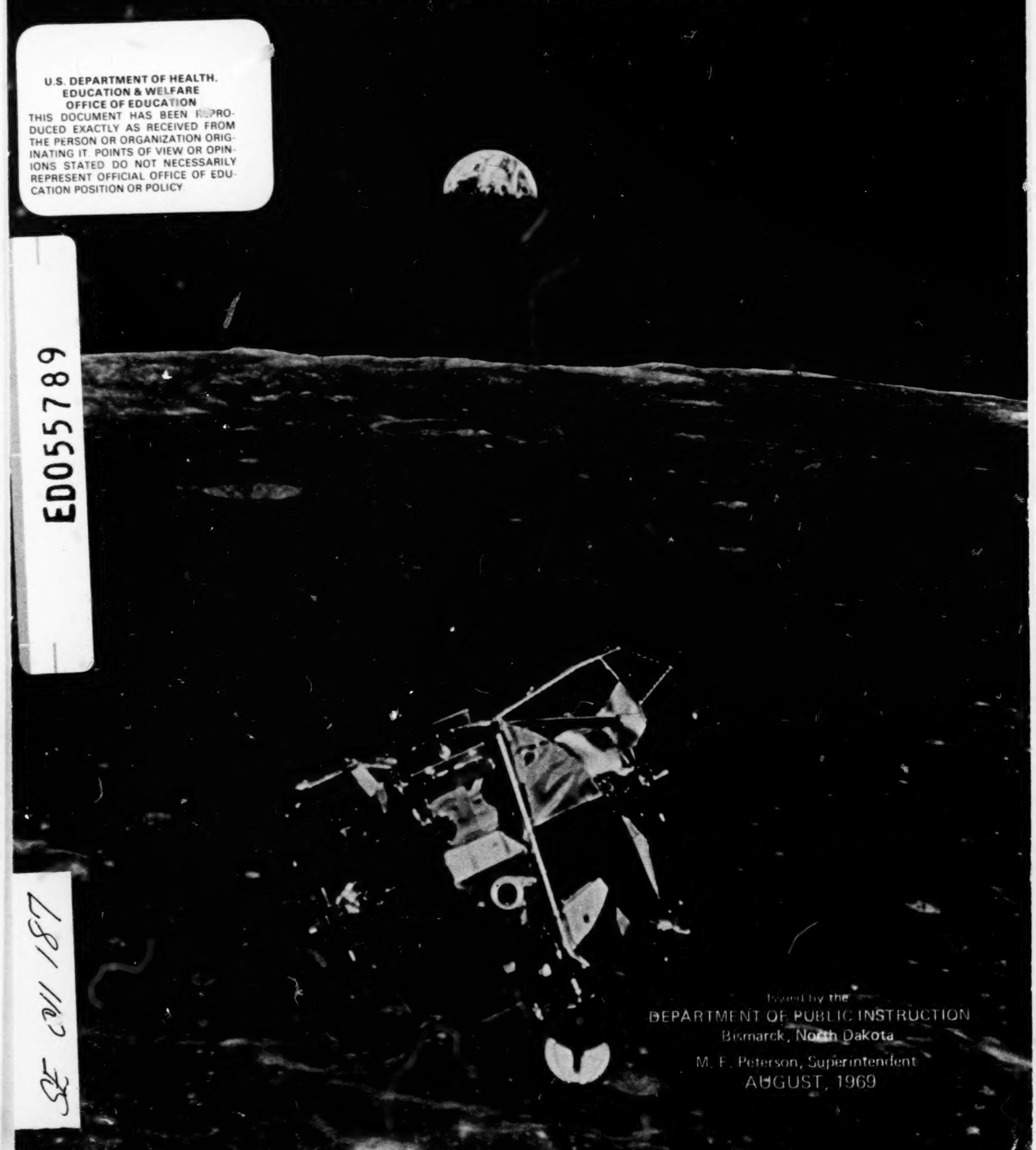

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Issued by the
DEPARTMENT OF PUBLIC INSTRUCTION
Bismarck, North Dakota
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ELEMETARY

SCIENCE GUIDE

GRADES 1 THROUGH 6

Issued by

Department of Public Instruction
Bismarck, North Dakota

M. F. PETERSON, *Superintendent*

August, 1969

"BUY NORTH DAKOTA PRODUCTS"

Preface

What should be the nature of a science guideline for the elementary schools of North Dakota?

Some expressed a desire to have a curriculum guide presenting a course of study to be followed by all of the schools of the State. Others considered the development of a science curriculum to be the responsibility of local schools and therefore the State guide should be only a topical outline emphasizing scope and articulation. The idea was also held that whatever form the guide takes, it should be adaptable for use with new content and new approaches in elementary school science.

Recognizing the broad divergence of views and the merit that attends each of them, this guide has been designed to be of optimum assistance to all views. For some, it can be viewed as containing the elements of a complete science curriculum. For others, it provides the working materials for incorporating original approaches that are relevant to a particular school.

The major purpose of this guide is to assist each school and administrative unit to develop a coordinated program in elementary science which is suitable to its own needs and resources. To accomplish this major objective, it offers suggestions which should help in the principal phases of program planning:

It sets forth sample objectives to be used in developing a significant list of behavioral objectives; outlines for developing a scope for the program; offers assistance in arranging a meaningful sequence; develops comprehensive units of study; offers a broad and varied set of practices for evaluation; and provides a wealth of information, activities, and resources for enriching the elementary school science program.

The present policy of the Department of Public Instruction states that grade one through six science is a full-year course. Health education may be a part of either the science program or the physical education program. If treated as a part of the science course, health should be interwoven into the entire year's work and not treated as a separate program. Agriculture, conservation, and environmental education concepts must also be woven into the general science curriculum of elementary schools.

"The Health Instructional Guide for North Dakota Schools," grades 1 - 12, published in 1965 by the Department of Public Instruction, should be used to determine material to be stressed in health.

"BUY NORTH DAKOTA PRODUCTS"

Foreword

Teachers at all levels, supervisors, administrators, and members of State Departments of Public Instruction have been concerned with the type of science programs and the status of science education for many years. Authors such as Craig, Hill, Blough, Croxton, Blackwood, Fraiser, Decker, McCracken, and many others have devoted a lifetime to elementary science. The seeds they planted prior to the concern for the status of science education, which developed a decade or so ago, have matured.

Numerous projects receiving funds from the Federal Government and private foundations enabled specialized personnel to try out, improve and enlarge upon the ideas, concepts, and objectives of those developed by the leaders in an earlier era.

These projects had one common purpose; to upgrade existing science programs through curriculum revision. One by one, but without exception, the projects came up with the same harsh facts regarding then current elementary science programs: teachers were not teaching science in an effective manner in light of our new learnings, but even more important, many students were not gaining an adequate insight into science and the ways of science, a realization that was long overdue.

The major objective of science curriculum projects is the development of a program which provides students with the opportunity to investigate in a meaningful manner the world in which they live. The investigations should be loosely structured in order to allow for individualization and the practice of the processes of inquiry. Such a practice is important for all students and not simply those planning scientific careers, for such processes help to provide students with the necessary tools for obtaining their own answers to their own questions. Appropriate materials and procedures should provide the elements necessary for the successful completion of this objective.

Students should pursue their quest for scientific knowledge as they desire but should be given opportunities for laboratory activities stressing active involvement. As a corollary to the new awareness of our educational shortcomings, almost without exception, the elementary science projects now began to develop new science programs that were heavily equipment-oriented; programs that were intended to extract the learner from the confines of the text and to allow his natural curiosity to blossom fully in the lab-centered atmosphere. The major premise which guided the development of the new materials was that students learn better and retain information for longer periods of time if they increase the involvement of the tactile senses. No small point should be made of the fact that students were at last becoming more involved in learning and enjoying it—something about which every elementary teacher should be concerned. To witness the abundance of enthusiasm generated by youngsters involved in an activity-centered science program is indeed a joy to behold.

If we were to accept a popular definition of science as an accumulated and systematized body of knowledge, we would be only partially defining science. To claim that science is merely a compendium of facts and laws is just as ridiculous as defining a bird to be a pile of feathers, or a tree to be a mass of leaves. The process of reasoning, the process of inquiry, and the process of investigation are the heart of science.

At the elementary level, the process by which students obtain information is as important as the information itself. It matters not whether we study the growth rate of germinating seeds, explore the world of light and shadows, or investigate the properties of liquids; the content is merely the median through which we teach the processes. Some processes which elementary students might develop are: observing, classifying, measuring, predicting, recording and analyzing data, formulating hypotheses, manipulating scientific equipment, and experimenting. The development of these processes should occur in an informal atmosphere as a natural outgrowth of scientific experiences.

It is hoped that by exemplary actions, teachers will discover methods of freeing their students to develop their rational powers, the essence of critical thinking.

M. F. PETERSON
Superintendent of Public Instruction

Acknowledgment

This Science Guide, grades 1 - 6, has been developed as a part of the twelve-year science program under the direction and leadership of members of the Department of Public Instruction, assisted by committee members of science teachers, supervisors, and administrators.

George Fors, Science Consultant of the Department of Public Instruction, has been primarily responsible for the organization and direction of this project. Kiaran L. Dooley, Director of State and Federal Relations, and S. R. Lacher, Audio Visual and Humanities, have served in a consultative capacity, and have reviewed much of the content.

This is the first major guide in science for grades 1 - 6 since 1948, although many helps have been sent to schools and elementary teachers during the past ten years. It is intended to be a part of the scope and sequence of the study of science in grades 1 - 12.

We wish to acknowledge the part others have helped by providing us with material. Arizona, Florida, New York, North Carolina, West Virginia and other states made their materials available. Scientific supply companies, book publishers, Chicago Public Schools, and the Department of Health, Education, and Welfare were additional sources of information. Significant contributions were made by the persons listed below.

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Part One

Elementary Science

Objectives of Elementary Science

As one takes a critical look at the elementary-school child, several basic needs seem to be apparent. He needs to gain command of the basic skills of reading, writing, arithmetic; he needs to be able to communicate effectively; he needs to feel right about himself and others.

The objective of education is ". . . to help children gain the ideals, understandings, and skills essential to becoming good citizens." More specifically, the study of science in the elementary school should "help boys and girls come to know some generalizations or big meanings or science principles that they can use in solving problems in their environment." Memorization of bits of scientific knowledge to parrot back to the teacher is not an objective of elementary science. Elementary science should help children:

1. To learn to respect the tentative nature of scientific data and conclusions.
2. To understand that change, a cause-and-effect relationship, has been, is, and will continue to be a fundamental phenomenon in the universe in which they live.
3. To develop laboratory skills.
4. To develop communication skills.
5. To practice critical thinking through problem-solving activities and to recognize the applications and limitations of such procedures in non-science problems.
6. To appreciate the inter-relationships of science.
7. To develop hospitable attitudes toward initiative, resourcefulness, imagination, curiosity, and creative activity.
8. To increase understandings of themselves and of their relationships to their universe.
9. To retain their enthusiasm for seeking more and more knowledge.
10. To accept the challenge that society needs their best talents and wisdom.
11. To explore science for new interests, continually evaluating science experiences for career and recreational opportunities.

What I hear, I may forget
What I see, I may remember
But what I do, I will know.
(Lead us to learning; then step
aside and let us learn.)

Purpose and Use of the Guide

This guide was compiled to point the way and to assist in the development of local elementary school science programs. It should be used only as a guide, not as a definite procedure to be followed step by step. Each teacher should feel free to use the steps individually or as a whole depending on the type of problem or question being considered in a particular classroom situation.

This curriculum guide will not in itself improve science learning in the schools in North Dakota. Teachers and administrative personnel are the key factors in developing a meaningful elementary science program.

Teachers should not be "tied" to a single textbook nor to a page by page coverage of material. Opportune timing and student desires may be major factors influencing the order of units to be investigated.

Science is action; not a segmented subject with positive answers and absoluteness. Science is drawn from natural happenings and situations in everyday experiences from baking a cake to studying rock formations. "Hows and whys" involve everyone. Children live in a world of science. They become curiously involved through observation, inquiry, and interaction with each other. The job of the science teacher is to keep this attitude alive by guiding the child to explore the mysteries of science through direct involvement in problem solving.

Let us remember to take the class out of doors and to bring subjects of study into the classroom. Investigating one's environment is the most interesting and integral part of science education. The foundation of all learnings in science is first hand experience with real things. To supplement real things, filmstrips, films, film loops, models, slides, study prints, transparencies, and reading materials will reinforce learning.

Science experiences need not involve unusual, elaborate, or expensive apparatus and material. Child involvement in unit planning and preparation of needed unit materials provide a more meaningful experience.

Scientific Thinking

Science is a method as well as a body of organized knowledge. The scientific method is not an inflexible pattern of steps that must be followed. Each problem, or question may be approached by a number of steps, but which steps and in what order, depends upon the nature of the problem.

Science education is child-centered and therefore should evolve around problems or questions identified by the children. Students should be taught to approach problems through a series of steps as questioning, exploring, experimenting, observing, measuring, and concluding.

Each science experience in which the students become involved is somewhat different from other experiences; therefore, the teacher will use various techniques for introducing a particular experience. In some cases there may be a series of questions raised by the students for which answers may be discovered. In other cases, teachers may need to lay the factual groundwork prior to student involvement. In either case, the teacher should be the motivating agent rather than the dominating factor.

Science must be a balanced combination of many things, and to emphasize any single part while neglecting others is to cheat children of the real appreciation of the tool with which man may one day conquer the universe.

QUESTIONING

The first scientist was the first person who ever wondered about something and set out logically to discover an answer. Wondering is the very foundation of science. No scientific method can operate unless some question has first been posed. The only restriction to the questioning is that each problem must be specific and limited. "I wonder about the world" will lead to no conclusion until it is rephrased and limited to "I wonder how big the world is" or "What is the shape of the world?" and so on.

Throughout the lesson, questions will arise from the children. The teacher need not provide answers to these questions; rather she should encourage additional investigative techniques that may support discoveries or challenge the students to further investigation or a final conclusion.

Question-asking can and should be a major factor of the teacher's planning for her pupil's progress in the classroom. Many of the objectives can be enhanced, depending upon the wise use of questions. Questions may be classified into two categories; they are divergent and convergent type questions.

Divergent questions are those questions that would lead to further questions elicited from the students, cause children to plan experiences with materials or to foster the kind of inquiry that would instill the children to do further research or investigation of the topic. All of these questions require thinking, will perhaps augment the scope of the material being studied, and will probably enhance the interests of at least some of the students in the topic under consideration. Other questions can be classified as convergent. Convergent type questions tend to cause children to summarize and draw conclusions. Convergent questions may be helpful in bringing about the grouping or regrouping of experiences which may lead to generalization and understanding. The simple recall of facts will fall into the convergent category. The importance of convergent questions may be limited and careful consideration should be applied when they are used.

Robert Karplus and Herbert D. Thier present a verbal sequence that took place in a third grade class. This sequence will be utilized here for differentiating between convergent (C) and divergent (D) type questions.

Teacher: How do goldfish get air? (D)

Pupil: The fish takes water in his mouth and by moving his stomach back and forth pushes it past his gills. The gills take the air out of the water. The fish then takes water in through his mouth.

Teacher: That's very interesting. What do some other poeple think? (D)

Pupil: When this fish needs air, he comes to the top and sticks his mouth out and gulps some.

Pupil: I saw my goldfish at home do that. (Through discussion, it became apparent that more than half the class agreed with this second observation about gulping.)

Teacher: How many fish are there in the ocean? (C)

Pupil: Thousands.

Pupil: Millions!

Robert Karplus and Herbert D. Thier also state some precautions in question-asking. They are:

1. Questions that are extremely broad and not related directly to the experience of young children tend to be very confusing and overwhelming to them. For example, the question "How do fish get air?" must be preceded by many opportunities for the children to observe fish if their answers are to have any meaning.
2. The technique of tabling a correct answer (as in the case of the fish) in order to explore the other children's conception of the problem is valuable, but must be used carefully. Young children and even many adults, have a tendency to accept as fact what their peers agree to en masse. If the teacher waits too long before showing (preferably by experience or discussion) the fallacy in a popular point of view, the children may latch onto it as fact.
3. Frequently one will use a question in order to encourage a child to explain his point of view more carefully or even to cause a child to reconsider what seems to be inaccurate or irrelevant point of view. This is a reasonable and meaningful use of the question-asking technique. Pupils should not, however, get the idea that every time the teacher asks questions it means she is displeased or not satisfied with a previous comment. One nice way to prevent this from happening is to ask the same kinds of questions of good students who have given perfectly acceptable answers.
4. A child's direct observations should not be evaluated as right or wrong. Instead, a question, such as "What is your evidence?" can be used to focus the child's attention on what has actually happened. This is particularly helpful when it appears there is a clear discrepancy between the event and the child's observation and report of it.

EXPLORING

A question is formed to be answered, but where is one to search for answers? In the fields, in the oceans, in the sky, inside our bodies, in books, in conversations, anywhere that the question may lead us is an area for exploration. A teacher must be careful not to instill in her pupils the fake notion that the scientist is a man in a white smock, confined to a laboratory.

Scientific exploring is done in and out of the classroom. It is done in books, in the field, in the laboratories and all other areas of the environment.

EXPERIMENTING

Sometimes there are conditions to be studied which seldom occur naturally or are difficult to observe. It is then that the scientist begins experimenting.

There is a very important part to experimentation that should not be neglected. Whenever any scientific experiment is carried out, there must always be a carefully designed check. This check is called the control. A control is designed to assure the

experimentor that he is investigating only those conditions being questioned.

Children can quickly see the need for controls if they are given a few simple examples. After they have an understanding of the concept of control, they should design their own "experiments" and learn to be critical of their own observations and conclusions. Depending upon the experience available to them, pupils should come to see that no single experiment really "proves" anything. The better the controls, the more reliable will be the conclusions reached, *but always conclusions — never proofs.*

A demonstration performed for the class is seldom an experiment. Pupil-conducted laboratory activities, such as confirming the law of the lever, are not experimental in nature. An activity is an experiment only when the observer is unsure of the results. An experiment is designed to discover new relationships; it reveals new knowledge.

If one refers to all manipulation of materials as "experiments," the word loses its true and important identity. It becomes synonymous with "activity."

It might also be noted that no experiment is ever a failure. The statement, "I tried the experiment, but it didn't work," implies a predetermined conclusion which is contrary to the method of science. If an activity "doesn't come out right," a real challenge has been presented; namely, what is the reason for the unexpected observation? A *demonstration* may fail, but an experiment *cannot* fail.

It is suggested that at the elementary level all experiments be kept simple and that the simplest materials are most desirable. Frequently, children originate and design their own experiments. With the guidance of the teacher, pupil-designed experiments provide the opportunity for children to understand the need for careful planning, careful observation, critical thinking, following directions, and the proper method.

The following ideas should be kept in mind when introducing and developing a program of experimentation in elementary school science:

1. Every experiment should be selected and performed in a manner which will help children think. Since the purpose of an experiment is to stimulate thought, its purpose is defeated if the teacher supplies the answers to the children.
2. Make certain the children are aware of the purpose of the experimentation. A statement of the purpose may serve to direct the thinking of the children as the experimentation is being performed.
3. Children should perform the experimentation themselves. The youngsters may work individually, in pairs, or in small groups, depending on the type of experiment and the amount of available equipment and materials.
4. Youngsters frequently devise original experiments in an attempt to discover answers to questions that may have occurred to them. Such experiments should be encouraged and whenever feasible, the originator should perform the experimentation as a class demonstration.

5. Experimentation should be performed carefully and in accordance with simple directions understood by all children.
6. Youngsters should be aware of the importance of critically observing all the happenings during the experiment so that they may obtain accurate results.
7. Pupils should be led to understand that generalizations should not be made from a single experiment. They should be aware that frequently an experiment must be performed more than once, and that scientists actually redo experiments many times to obtain accurate and valid conclusions.
8. Applications to everyday life situations may be made from the conclusions of an experiment.

Children should be encouraged to record their own notes concerning the experimentation.

This method provides the means for establishing sound scientific study habits since the gathering and recording of information is essential for proper scientific work.

Upon completion of the experimentation, a thorough discussion should be held to review the facts discovered through the activity to focus attention on the concepts developed.

"Invitation to Experiment" in Volume III, page 289, of the *Elementary Science Source Book* should be read by all teachers.

OBSERVING

The information gained from any exploration or experimentation is limited by one's scope of observation. The term, observation, is used here in its broadest meaning and includes all of what we may perceive from any of our senses—sight, smell, touch, taste, or hearing.

It is probably in this particular area of scientific investigation that one must be most aware of human error. There are times when information is altered or partially blocked before it reaches our senses, so our interpretation is not entirely correct. All the stimulations received by our senses must be interpreted by our minds; therefore, any mental set will greatly affect our observations.

The initial observation should focus upon those questions raised by the students or upon the framework provided by the teacher. The initial observation will probably be very broad in scope and will stimulate additional questions. The whole process may begin with the question, "What do you observe?" For acceptable scientific observation, one must observe from every possible vantage point and evaluate *all* findings. The whole process may be more meaningful and exact if the student records each observation as it is made. The record must describe rather than explain that which is observed. The tabulation should be short, descriptive phrases with clarifying sketches.

Interpretive observations are made from the observed observations. The student will assimilate his observations and interpret them as they relate to his problem. For example, the student may have observed in an experimentation activity that a growing plant lost its green color and eventually died when shut off from sunlight or he may have reflected that a plant that has grown in a dark place does not have a green color. He may interpret that it was the absence of sunlight that caused the green plant to lose its color, not the absence of water, warmth, etc. He could then conclude or draw from this that in order for plant life to exist, sunlight is necessary.

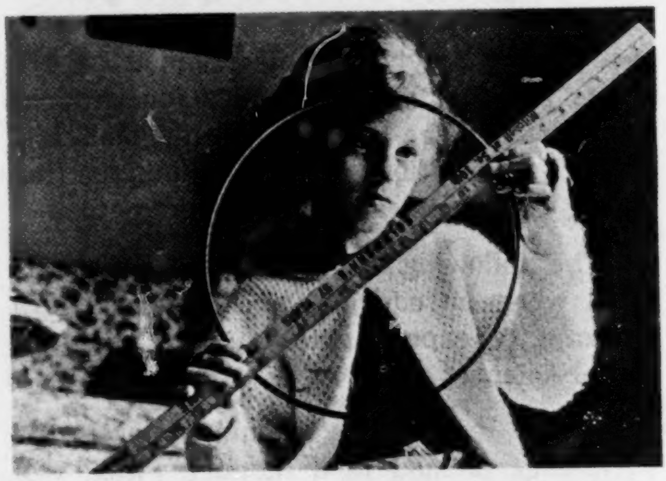
When possible, students should expand their observations to compare or confirm what they have observed or discovered. During the comparisons, the observer should record only that information that is relevant to the primary questions.

Observations should generally be left open to further experimentation, but may lead to further questions or conclusions.

Read "Science Experiments in the Classroom," Volume II, page 255, in the *Elementary Science Source Book.*

MEASURING

The aspect of measurement in the scientific procedure is too often neglected in the classrooms, yet it is here that science may be easily integrated with other areas of the curriculum. Measurement is an im-

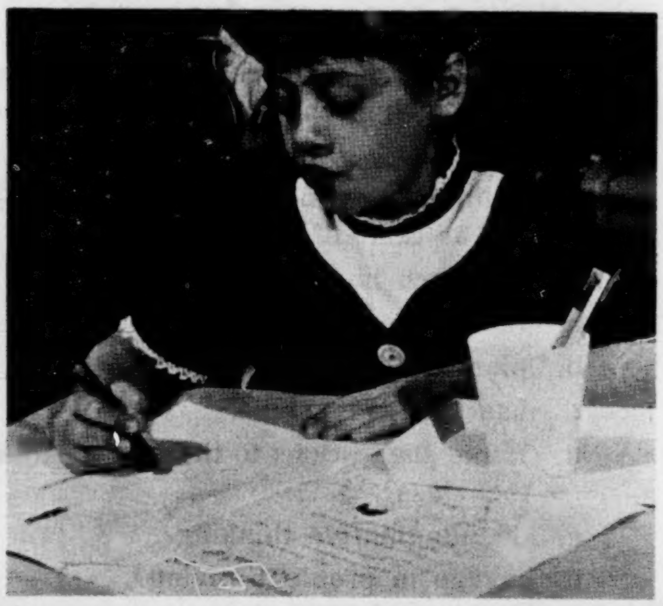


portant portion of fundamental arithmetic. In fact, each child has learned to judge and estimate quantities long before school age. To learn to walk, as well as to run and jump, involves a great deal of judgment which is certainly measurement.

Although the advanced sciences require higher mathematics as one of the tools of measurement, all scientific observation, even on the simplest level, requires some type of measurement. To find out, you must measure heights or growth rates. How many? How much? How long?—All are questions which lead to measurement.

The skills involved in making measurements will develop with pupil maturity. In the primary grades measurement of time by clock and calendar, of quantity by counting, and of length by ruler can be used effectively. Later, as the child develops, his problems become more involved and will require the use of more complex measurements.

Besides learning the physical process of making a measurement, pupils should become aware of some related concepts. During the intermediate grades, or even before, an appreciation of accuracy should develop. How long is a desk? The answers you may find will be determined by the measuring device used and the care with which it is used. Actually, no measurement can be perfect. All that we can do is to be more and more careful in order to get more and more accuracy.



All measurements are, in the final analysis, made with human senses and the mind. Measuring instruments are but extensions of our senses, and we must finally interpret the data from the instrument. The microscope and telescope do not replace our eyesight but extend its natural capability. A ruler serves as a standard of comparison, but we still have to compare visually the length of an object to the markings on the ruler. And so it is with all instruments of measurement; our own senses make the final judgment, and we are always subject to human error and limitations.

Read "Let's Measure," Volume II, page 61, in the *Elementary Science Source Book.*

CONCLUDING

Following the exhaustion of all available sources of information, the scientist next attempts to draw some generalizations or conclusions.

We have not the time nor the energy to test every possible case, so we must draw each conclusion from a limited number of observations. Experiments are compared to controls; observations are most carefully made; yet there is always the possibility that errors were made or some evidence was unnoticed. For such reasons, the results of scientific exploration should never be stated as hard, inflexible "facts." Not only must pupil and teacher bear in mind the limitations in their conclusions, but even the experienced scientist respects the same restrictions.

As a result of the problem-solving activity, the student may now be able to make a prediction about his environment.

Suggestions for the Elementary Teacher

Critical thinking can be stimulated just as well by the experiment that didn't "work."

Don't worry about not being able to explain the scientific principle behind each experiment. What happens is more important then "why" at this stage of the game.

Don't think it necessary to keep up ceaseless chatter as the investigation progresses. Give students a chance to observe and perceive.

Choose experiments that you think are fun. The children will probably agree.

An experiment is a form of inquiry; a visual aid is a visual aid.

Have no concern for not having answered all the questions, but be sure that you have not discouraged the asking.

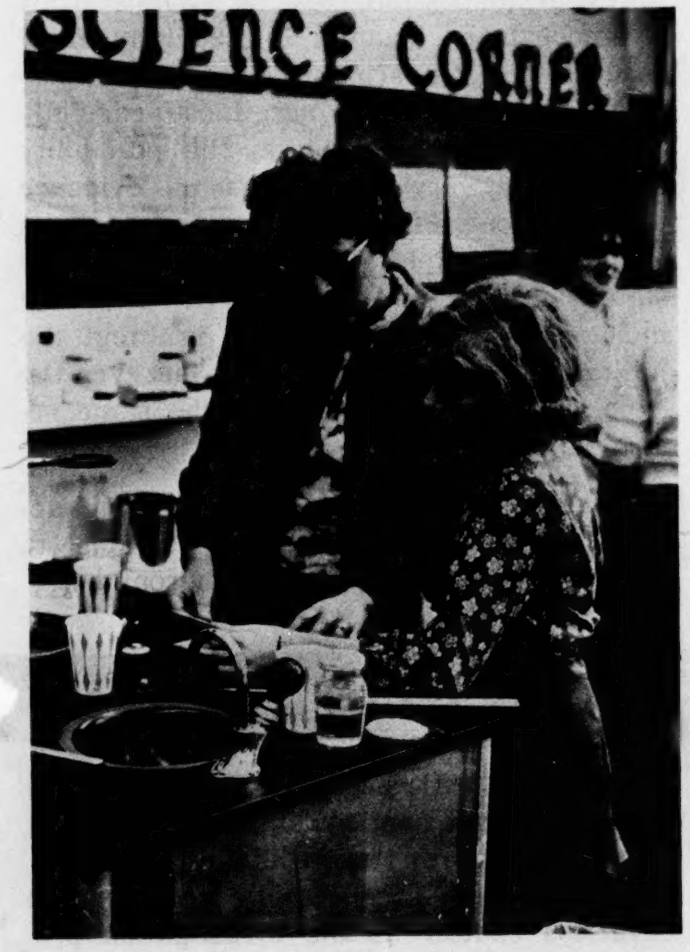
Evaluation

Evaluation is a continuous process which is an integral part of teaching. Evaluation goes on continuously during lessons and units and is closely related to the teacher's goals. It should be recognized that a teacher should evaluate her progress as well as that of the children. Evaluation must be in terms of what is happening to the learner. Methods of evaluation should include some or all of the following.

HOW SHALL WE EVALUATE OUR EFFORTS AND RESULTS

Two points must be kept in mind:

1. Evaluation by teacher and children is part of every phase of an experience. It is not something that takes place only at the end.



2. Evaluation must be in terms of what is happening to the learner. Methods of evaluation should include some or all of the following:
    a. Pupil behavior records which indicate changes noted in the course of the experience.
    b. Work products of children judged on the basis of individual capacity.
    c. Teacher-pupil interviews, inventories, questionnaires.
    d. Problem situation tests.
    e. Concise essay exams.
    f. Multiple choice —

CRITERIA FOR EVALUATION OF SCIENCE EXPERIMENTS

1. What were the science experiences in which the children engaged?
2. What is the area of human experience or environment to which the children's activity was related?
3. Did children have opportunity to
    a. manipulate materials?
    b. plan experiments?
    c. use language skills?
    d. make suggestions to the teacher and the class?
    e. do imaginative thinking?
    f. engage in problem-solving?
    g. evaluate conclusions?
4. Was opportunity provided for group work?
5. Was opportunity provided for individual patterns of ability and understanding?
6. Was opportunity given children to use previous experience in the present experience?

7. Were the materials used simple and at hand?
8. Did the problem studied seem to be meaningful to pupils?
9. Did the teacher help the children to understand realistic application of conclusions?
10. What evidences were there that the children enjoyed the science experience?

TEACHER'S CHECKLIST IN ELEMENTARY SCIENCE

To measure the effectiveness of school practices and procedures in teaching science, the teachers may periodically and systematically check on the children's growth in the following areas.

	None	Some	Much
1. In my teaching is there opportunity or provision for children to:			
a. Raise questions and problems of importance or interest to them?			
b. Study these questions and problems?			
c. Help plan "things to do" in studying science problems?			
d. State clearly the problems on which they are working?			
e. Make hypotheses to be tested?			
f. Gather accurate data (information) in a variety of ways:			
Through reading on the subject?			
Through taking field trips?			
Through watching demonstrations?			
Through doing experiments?			
Through talking to resource persons?			
g. Analyze the data (information) to see how it relates to the problem?			
h. Think about the applications of their science learnings to everyday living?			
i. Think about science relationships and processes instead of merely naming things and learning isolated facts?			
j. Bring science materials of different kinds to school for observation and study?			
k. Engage in individual science interests?			

IN MY TEACHING

do I periodically and systematically check on the children's growth in:

	None	Some	Much
a. Ability to locate and define problems right around them?			
b. Acquiring information on the problem being studied?			
c. Ability to observe more accurately?			
d. Ability to make reports on or record their observations?			
e. Ability to solve problems?			
f Ability to think critically?			
g. Ability to explain natural phenomena?			
h. Ability to distinguish between facts and fancies?			
i. Suspending judgment until evidence is collected?			
j. Being open-minded or willing to change belief?			
k. Co-operating with others?			
l. Understanding the cause and effect relationships of events?			
m. Skill in using some common scientific instruments (thermometers, scales, rules, etc)?			

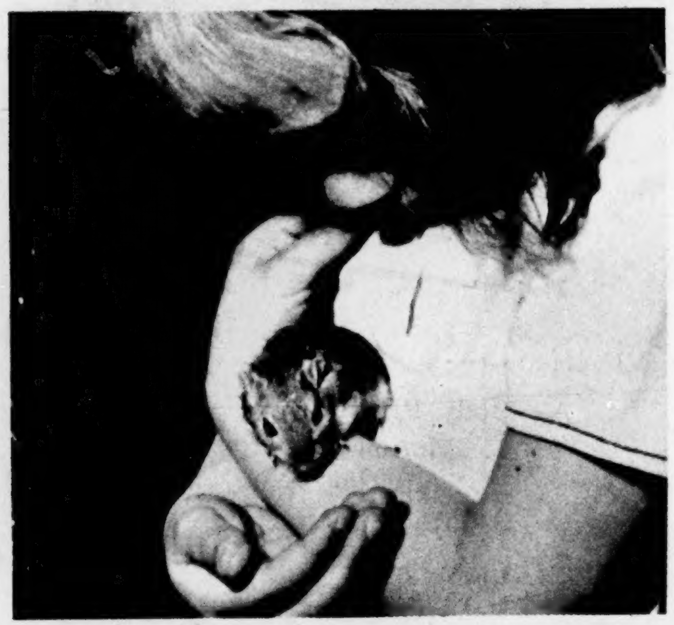
Part Two

Applications

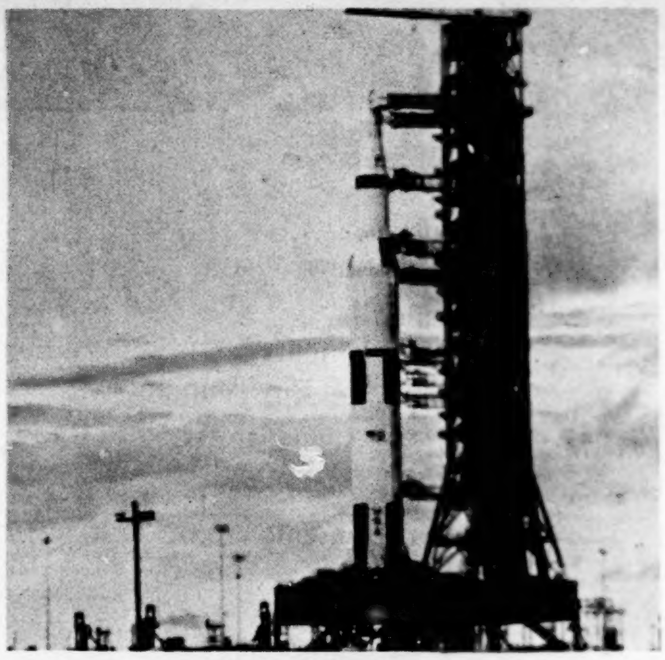
Outline

Utilizing the suggested principles of good science teaching, the program for grades 1-6 should involve the students in active investigation of certain essential segments of his environment. Such involvement should progress from simple investigation and observation to inquiry in depth as the pupil matures. The teacher is urged to utilize a variety of educational media, textbooks, reference books, and laboratory equipment to encourage pupil investigation in the following broad areas.

I. Living Things
  - A. Plants (Student's Environment)
    1. Characteristics
    2. Classifications
    3. Life Processes



  - B. Animals (Student's Environment)
    1. Characteristics
    2. Classifications
    3. Activities
  - C. Interdependence and Co-existence Including Man
  - D. Conservation



II. Beyond the Earth
  - A. Solar System
    1. Components
    2. Relationships
    3. Movements
    4. Effect on Environment
  - B. Stars and Space
    1. Constellations
    2. Distances
  - C. Time—Space Relations

III. Earth
  - A. Soil
    1. Kinds - Origins
    2. Conservation
  - B. Rock
    1. Classification
    2. History
    3. Fossils
  - C. Waters
    1. Water Cycle
    2. Effect on Environment
    3. Conservation

D. Weather
1. Causes
2. Predictions

E. Atmosphere
1. Measurements
2. Effect on Environment

IV. Matter

A. Solids
1. Measurements
2. Structure
3. Movements

B. Fluids (Liquids - Gases)
1. Measurements
2. Structure
3. Movements

V. Energy

A. Heat
1. Nature
2. Measurement

B. Light
1. Nature

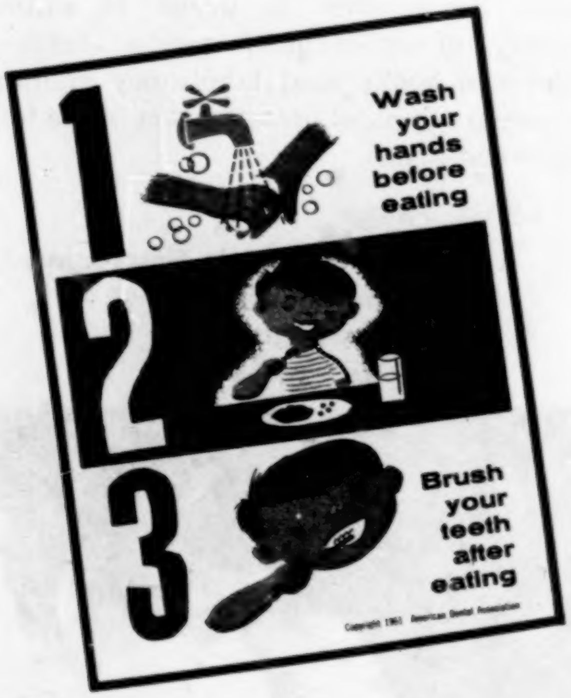
2. Measurement
3. Vision

C. Vibration and Sound
1. Nature
2. Communication
3. Hearing

D. Magnetism
1. Sources
2. Effects
3. Relationships

E. Electricity
1. Sources
2. Effects
3. Relationships

F. Force and Motion
1. Gravity
2. Movements
3. Machines


1
Wash your hands before eating
2
3
Brush your teeth after eating
Copyright 1961 American Dental Association

VI. Health

A. Body Process
1. Motion
2. Nutrition
3. Reproduction

B. Cleanliness
1. Micro-organisms
2. Protection

Science Investigations

The *Elementary Science Handbook*, published by the Department of Public Instruction, can be of much help to elementary teachers to provide meaningful activities for students. For the teacher's convenience, the following pages indicate how the outline on the preceding page may be correlated with the North Dakota *Elementary Science Handbook*. There are many other activities that also apply.

I. Living Things

A. Plants

1. Characteristics

1-3		3-5		5-6	
no. 1901	p. 293	no. 2511	p. 288	no. 2529	p. 291
no. 1905	p. 294	no. 2529	p. 291	no. 2530	p. 291
no. 1906	p. 295	no. 2534	p. 292	no. 2534	p. 292

2. Classifications

1-3		3-5		5-6	
no. 1006	p. 332	no. 1905	p. 294	no. 1003	p. 332
no. 1924	p. 298	no. 1924	p. 298	no. 1922	p. 298
no. 2520	p. 289	no. 1925	p. 298	no. 1942	p. 303

3. Life Processes

1-3		3-5		5-6	
no. 2529	p. 291	no. 1937	p. 302	no. 1901	p. 293
no. 2530	p. 291	no. 1938	p. 302	no. 1934	p. 301
no. 2534	p. 292	no. 1944	p. 303	no. 1942	p. 303

B. Animals (Student's Environment)

1. Characteristics

1-3		3-5		5-6	
no. 2903	p. 306	no. 2904	p. 306	no. 2905	p. 307
no. 2904	p. 306	no. 2919	p. 313	no. 2907	p. 308
no. 2908	p. 309	no. 2905	p. 307	no. 3044	p. 230

2. Classifications

1-3		3-5		5-6	
no. 2903	p. 306	no. 2918	p. 313	no. 2938	p. 317
no. 2904	p. 306	no. 2938	p. 317	no. 2943	p. 317
no. 2911	p. 310			no. 3917	p. 326

C. Interdependence and Co-existence Including Man

1-3		3-5		5-6	
no. 2920	p. 313	no. 3904	p. 321	no. 2912	p. 310
no. 2922	p. 314	no. 3913	p. 325	no. 3916	p. 326
no. 3901	p. 319			no. 3919	p. 327

D. Conservation

1-3		3-5		5-6	
no. 2922	p. 314	no. 2045	p. 358	no. 2023	p. 353
no. 3916	p. 326	no. 2052	p. 360	no. 3919	p. 327
no. 3946	p. 330			no. 3946	p. 330

II. Beyond the Earth

A. Solar System

1. Components

1-3		3-5		5-6	
no. 2717	p. 455	no. 3757	p. 424	no. 2717	p. 455
no. 2722	p. 456	no. 3758	p. 425	no. 2722	p. 456
no. 3748	p. 419	no. 3759	p. 426	no. 2723	p. 456

2. Relationships

1-3		3-5		5-6	
no. 2706	p. 453	no. 3754	p. 422	no. 2707	p. 453
no. 2709	p. 454	no. 3757	p. 424	no. 2720	p. 455
no. 3756	p. 423	no. 3758	p. 425	no. 2722	p. 456

3. Movements

1-3		3-5		5-6	
no. 1727	p. 450	no. 3754	p. 422	no. 1701	p. 443
no. 2705	p. 453	no. 3755	p. 422	no. 1724	p. 449
no. 2708	p. 454	no. 3758	p. 425	no. 1727	p. 450

4. Effect on Environment

1-3		3-5		5-6	
no. 3636	p. 435	no. 3644	p. 436	no. 3661	p. 442
no. 3735	p. 415	no. 3751	p. 419	no. 1701	p. 443
no. 3728	p. 412	no. 3636	p. 435	no. 1713	p. 445

B. Stars and Space

1. Constellations

1-3		3-5		5-6	
no. 2726	p. 458	no. 3750	p. 419	no. 2727	p. 458
no. 2727	p. 458	no. 3753	p. 420	no. 2731	p. 459
no. 2734	p. 461	no. 3757	p. 424	no. 3758	p. 425

2. Distances

1-3		3-5		5-6	
no. 2720	p. 455	no. 3750	p. 419	no. 2729	p. 459
no. 2729	p. 459	no. 3756	p. 423	no. 2730	p. 459
no. 3756	p. 423	no. 2730	p. 459	no. 3752	p. 420

C. Time-Space Relations

1-3		3-5		5-6	
no. 3701	p. 397	no. 3749	p. 419	no. 2730	p. 459
no. 3706	p. 398	no. 3752	p. 420	no. 3757	p. 424
no. 3710	p. 402	no. 3759	p. 426	no. 3759	p. 426

III. Earth

A. Soil

1. Kinds-Origins

1-3		3-5		5-6	
no. 2808	p. 271	no. 1837	p. 268	no. 1838	p. 268
no. 2811	p. 271	no. 1838	p. 268	no. 2802	p. 270
no. 1830	p. 265	no. 3911	p. 325	no. 2807	p. 271

2. Conservation

1-3		3-5		5-6	
no. 1825	p. 263	no. 2820	p. 273	no. 2841	p. 279
no. 2821	p. 274	no. 2821	p. 274	no. 3906	p. 322
no. 2823	p. 275	no. 2824	p. 275	no. 2833	p. 278

B. Rock

1. Classification

1-3		3-5		5-6	
no. 1807	p. 261	no. 1804	p. 259	no. 1804	p. 259
no. 1808	p. 261	no. 1806	p. 261	no. 1805	p. 259
no. 2803	p. 270	no. 1807	p. 261	no. 1810	p. 261

2. History

1-3		3-5		5-6	
no. 1803	p. 259	no. 1801	p. 258	no. 2851	p. 283
no. 1810	p. 261	no. 2838	p. 278	no. 2852	p. 284
no. 1829	p. 265	no. 2843	p. 279		

3. Fossils

1-3		3-5		5-6	
no. 1813	p. 262	no. 1825	p. 263	no. 1841	p. 268
no. 1817	p. 262	no. 1841	p. 268	no. 1842	p. 269
no. 1823	p. 263	no. 1842	p. 269	no. 1845	p. 269

C. Waters

1. Water Cycle

1-3		3-5		5-6	
no. 2613	p. 144	no. 3628	p. 433	no. 2433	p. 86
no. 2617	p. 145	no. 3629	p. 433	no. 3636	p. 435
no. 3630	p. 433	no. 3631	p. 433	no. 2610	p. 144

2. Effect on Environment

1-3		3-5		5-6	
no. 2529	p. 291	no. 2529	p. 291	no. 2820	p. 273
no. 3804	p. 186	no. 2534	p. 292	no. 3807	p. 187
no. 3805	p. 186	no. 2824	p. 275	no. 3808	p. 187

3. Conservation

1-3		3-5		5-6	
no. 2820	p. 273	no. 3823	p. 193	no. 3904	p. 321
no. 3809	p. 188	no. 2807	p. 271	no. 3905	p. 321
no. 3827	p. 194	no. 2809	p. 271	no. 3902	p. 321

D. Weather

1. Causes

1-3		3-5		5-6	
no. 1636	p. 167	no. 3636	p. 435	no. 3644	p. 436
no. 1637	p. 167	no. 3644	p. 436	no. 3654	p. 439
no. 3654	p. 439	no. 3654	p. 439	no. 3659	p. 441

2. Predictions

1-3		3-5		5-6	
no. 3609	p. 430	no. 3620	p. 431	no. 3642	p. 436
no. 3614	p. 430	no. 3638	p. 435	no. 3643	p. 436
no. 3617	p. 431	no. 3622	p. 432	no. 3623	p. 432

E. Atmosphere

1. Measurements

1-3		3-5		5-6	
no. 1632	p. 165	no. 2603	p. 142	no. 2603	p. 142
no. 3602	p. 428	no. 2608	p. 144	no. 3607	p. 429
no. 3607	p. 429	no. 3601	p. 428	no. 3615	p. 430

2. Effect on Environment

1-3		3-5		5-6	
no. 1401	p. 169	no. 1602	p. 157	no. 1624	p. 163
no. 2640	p. 152	no. 1625	p. 163	no. 1625	p. 163
no. 2839	p. 278	no. 2617	p. 145	no. 1628	p. 163

IV. Matter

A. Solids

1. Measurements

1-3		3-5		5-6	
no. 1301	p. 111	no. 1311	p. 113	no. 1305	p. 112
no. 1307	p. 112	no. 3843	p. 198	no. 1313	p. 115
no. 1305	p. 112	no. 3844	p. 198	no. 2603	p. 142

2. Structure

1-3		3-5		5-6	
no. 2421	p. 82	no. 2420	p. 82	no. 2421	p. 82
no. 3505	p. 3	no. 2843	p. 279	no. 2419	p. 81
no. 3514	p. 5	no. 3416	p. 95	no. 2420	p. 82

3. Movements

1-3		3-5		5-6	
no. 2203	p. 37	no. 1336	p. 120	no. 1830	p. 265
no. 2233	p. 43	no. 2821	p. 274	no. 2801	p. 269
no. 3505	p. 3	no. 2841	p. 279	no. 2820	p. 273

B. Fluids (Liquids-Gases)

1. Measurements

1-3		3-5		5-6	
no. 1348	p. 123	no. 1631	p. 165	no. 1606	p. 157
no. 1602	p. 157	no. 3506	p. 4	no. 1608	p. 159
no. 3506	p. 4			no. 1616	p. 161

2. Structure

1-3		3-5		5-6	
no. 1642	p. 168	no. 2639	p. 152	no. 1602	p. 157
no. 3516	p. 7	no. 3441	p. 104	no. 3424	p. 97
no. 3636	p. 435	no. 3516	p. 7	no. 3441	p. 104

3. Movements

1-3		3-5		5-6	
no. 1617	p. 161	no. 3502	p. 2	no. 1617	p. 161
no. 1633	p. 165	no. 3837	p. 196	no. 1618	p. 162
no. 3835	p. 196	no. 3847	p. 198	no. 1619	p. 162

V. Energy

A. Heat

1. Nature

1-3		3-5		5-6	
no. 3655	p. 439	no. 3241	p. 68	no. 3525	p. 10
no. 3656	p. 440	no. 3401	p. 91	no. 1413	p. 173
no. 1405	p. 170	no. 3402	p. 91	no. 3537	p. 20

2. Measurements

1-3		3-5		5-6	
no. 1409	p. 172	no. 1457	p. 182	no. 3217	p. 55
no. 3602	p. 428	no. 1632	p. 165	no. 1420	p. 174
no. 3601	p. 428	no. 1637	p. 167	no. 1423	p. 174

B. Light

1. Nature

1-3		3-5		5-6	
no. 1502	p. 202	no. 1515	p. 206	no. 1518	p. 206
no. 1512	p. 204	no. 2505	p. 285	no. 1503	p. 202
no. 1517	p. 206	no. 2506	p. 286	no. 1509	p. 204

2. Measurements

1-3		3-5		5-6	
no. 2509	p. 287	no. 2502	p. 285	no. 3560	p. 22
no. 1520	p. 208	no. 1527	p. 208	no. 2509	p. 286
no. 2501	p. 285	no. 1534	p. 209	no. 1534	p. 209

3. Vision

1-3		3-5		5-6	
no. 1504	p. 202	no. 1521	p. 208	no. 1516	p. 206
no. 1513	p. 204	no. 1524	p. 208	no. 1535	p. 210
no. 1519	p. 206	no. 1531	p. 209	no. 1115	p. 389

C. Vibration and Sound

1. Nature

1-3		3-5		5-6	
no. 2619	p. 146	no. 2619	p. 146	no. 2621	p. 146
no. 2622	p. 147	no. 2621	p. 146	no. 2626	p. 147
no. 2624	p. 147	no. 2623	p. 147	no. 2628	p. 148

2. Communication

1-3		3-5		5-6	
no. 2625	p. 147	no. 2625	p. 147	no. 2627	p. 148
no. 2627	p. 148	no. 2627	p. 148	no. 2628	p. 148
no. 2622	p. 147	no. 2628	p. 148	no. 3231	p. 62

3. Hearing

1-3		3-5		5-6	
no. 2618	p. 146	no. 2618	p. 146	no. 2625	p. 147
no. 2621	p. 146	no. 2620	p. 146	no. 2621	p. 146
no. 2628	p. 148	no. 2621	p. 146	no. 3247	p. 71

D. Magnetism

1. Sources

1-3		3-5		5-6	
no. 2220	p. 41	no. 2201	p. 37	no. 2238	p. 44
no. 2201	p. 37	no. 2228	p. 42	no. 2239	p. 44
no. 2211	p. 39	no. 2245	p. 46	no. 2247	p. 46

2. Effects

1-3		3-5		5-6	
no. 2223	p. 41	no. 2205	p. 38	no. 2213	p. 39
no. 2233	p. 43	no. 2232	p. 43	no. 2233	p. 43
no. 2236	p. 44	no. 2233	p. 43	no. 2252	p. 48

3. Relationships

1-3		3-5		5-6	
no. 2223	p. 41	no. 3214	p. 54	no. 2242	p. 45
no. 2243	p. 45	no. 2242	p. 45	no. 2252	p. 48
no. 2218	p. 40	no. 2250	p. 47	no. 2253	p. 48

E. Electricity

1. Sources

1-3		3-5		5-6	
no. 1208	p. 26	no. 3202	p. 49	no. 1207	p. 26
no. 3201	p. 49	no. 3205	p. 50	no. 3207	p. 51
no. 3203	p. 50	no. 3208	p. 52	no. 3208	p. 52

2. Effects

1-3		3-5		5-6	
no. 1202	p. 24	no. 3204	p. 50	no. 3220	p. 56
no. 2248	p. 46	no. 3210	p. 53	no. 3226	p. 59
no. 1203	p. 24	no. 3211	p. 53	no. 3221	p. 57

3. Relationships

1-3		3-5		5-6	
no. 2242	p. 45	no. 1207	p. 26	no. 3212	p. 53
no. 3203	p. 50	no. 3249	p. 72	no. 3252	p. 74
no. 3201	p. 49	no. 3228	p. 60	no. 1219	p. 30

F. Force and Motion

1. Gravity

1-3		3-5		5-6	
no. 1301	p. 111	no. 1301	p. 111	no. 1346	p. 122
no. 1348	p. 123	no. 1303	p. 111	no. 1313	p. 115
no. 1307	p. 112	no. 1315	p. 116	no. 1314	p. 115

2. Movements

1-3		3-5		5-6	
no. 1328	p. 119	no. 1313	p. 115	no. 1343	p. 121
no. 3307	p. 126	no. 1315	p. 116	no. 1344	p. 121
no. 1342	p. 121	no. 3362	p. 139	no. 1334	p. 120

3. Machines

1-3		3-5		5-6	
no. 1309	p. 113	no. 1311	p. 113	no. 1322	p. 117
no. 1322	p. 117	no. 1316	p. 116	no. 1327	p. 118
no. 1323	p. 117	no. 1319	p. 117	no. 1313	p. 115

VI. Health

A. Body Process

1. Motion

1-3		3-5		5-6	
no. 3106	p. 362	no. 3107	p. 362	no. 3119	p. 368
no. 3107	p. 362	no. 3110	p. 364	no. 3110	p. 364
no. 3108	p. 363	no. 3119	p. 368	no. 3118	p. 368

2. Nutrition

1-3		3-5		5-6	
no. 2104	p. 379	no. 2101	p. 377	no. 2101	p. 377
no. 2108	p. 380	no. 2111	p. 380	no. 2114	p. 381
no. 2110	p. 380	no. 2114	p. 381	no. 2116	p. 381

3. Reproduction

1-3		3-5		5-6	
no. 2907	p. 308	no. 2908	p. 309	no. 2910	p. 310
no. 2908	p. 309	no. 2917	p. 312	no. 2921	p. 313
no. 2917	p. 312	no. 2920	p. 313	no. 2911	p. 310

B. Cleanliness

1. Micro-organisms

1-3		3-5		5-6	
no. 3035	p. 228	no. 1142	p. 395	no. 2108	p. 380
no. 3033	p. 228	no. 1145	p. 395	no. 2127	p. 385
no. 3045	p. 231	no. 3028	p. 226	no. 3145	p. 371

2. Protection

1-3		3-5		5-6	
no. 1142	p. 395	no. 1107	p. 388	no. 1116	p. 390
no. 1143	p. 395	no. 1122	p. 391	no. 1124	p. 391
no. 3138	p. 370	no. 1134	p. 394	no. 1127	p. 392

North Dakota Vertical Program in Science

Grade				
12	PHYSICS	Could Include or Become PSSC or Project Physics		
11	CHEMISTRY	Could Become Chem Study or CBA Types		
10	BIOLOGY	Could Become BSCS Type Program		
9	PHYSICAL SCIENCE	Lab. Procedures, Measurement, Machines, Sound, Light, Heat, Chem., Electricity		
8	EARTH SCIENCE	Astronomy and Space	Meteorology	Geology
7	LIFE SCIENCE	Living Things, Agriculture, Conservation	Human Body	
6	Living Things	Sky	Earth	MATTER & ENERGY
5	Living Things	SKY & EARTH	Matter & Energy	
4	LIVING THINGS	Sky	Earth	Matter & Energy
3	Living Things	Above the Earth	Earth	Matter & Energy
2	Living Things	Above the Earth	Earth	Matter & Energy
1	Living Things	Above the Earth	Earth	Matter & Energy

Blocks of time are suggestive for Grades 1-8

Scope

Elementary Science 1 - 6

The following pages contain a detailed outline which may serve as a guide for a school system which wishes to develop its own curriculum. Not all of these science materials can be covered. It is better to have fewer topics, study in greater depth, and let the students discover and investigate.

Using all resources available to you, prepare a scope for the science instructional program in your school. Discuss it thoroughly with the other teachers and develop a scope of science topics which you will use. The North Dakota Program on the preceding page can be used as a guide.

In developing this scope of science topics for the elementary schools it may prove helpful to take into consideration the types of science courses available to the children beyond grade six. Here are the courses which are offered to children as they continue their study of science in the upper six grades in North Dakota schools.

Grade 7	Life Science
Grade 8	Earth Science
Grade 9	Physical Science
Grade 10	Biology
Grade 11 or 12	Chemistry
Grade 11 or 12	Physics

I. INTRODUCTION TO SCIENCE

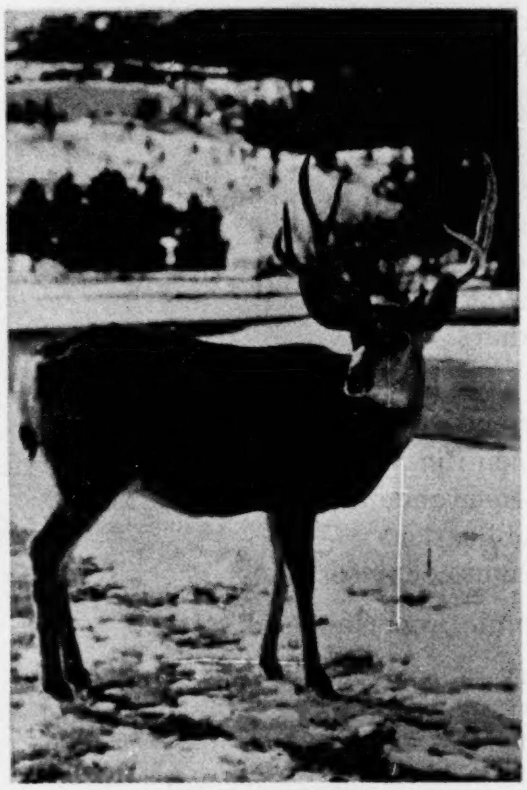
- A. What science is
- B. How science helps us
- C. What scientists are like
- D. How scientists think and work

  - 1. Scientific methods
  - 2. Scientific attitudes
  - 3. Scientific skills and abilities
- E. Branches of science
  - 1. Astronomy
  - 2. Biology
  - 3. Chemistry
  - 4. Geology
  - 5. Physics
  - 6. Others
- F. Tools of science
  - 1. Scientific apparatus
  - 2. Scientific vocabulary
  - 3. Measurements and computation
  - 4. Publications
  - 5. Professional societies
- G. Economic importance of science
- H. History of science
- I. Outstanding scientists—past and present
- J. Differences between pure and applied science

II. LIVING THINGS

- A. Our bodies
  - 1. Parts of our bodies
  - 2. Functions of our body parts
  - 3. Body systems
    - a. Structure of systems
    - b. Function of systems
  - 4. Body care
    - a. Cleanliness
    - b. Exercise
    - c. Rest and sleep
  - 5. Health and sanitation
    - a. Good personal health habits
    - b. Good public health habits
    - c. Germ theory of disease
    - d. Symptoms of common diseases
    - e. Spread of communicable diseases
    - f. Control of communicable diseases
    - g. Immunization
    - h. Sanitation
  - 6. Food
    - a. Kinds
    - b. Purpose
    - c. Four basic food groups

      (1) What each contains
      (2) Function
    d. Need for a balanced diet
    e. Good eating habits



B. Animals
  1. Animals around us
    a. Physical description
    b. Habitat
    c. Food habits
    d. Reproduction
    e. Growth and development
    f. Mobility
    g. Helpful and harmful effects
  2. How animals are alike and different
    a. Size and shape
    b. Color
    c. Habits
    d. Movement
    e. Growth
    f. Homes
    g. Sounds
    h. Reproduction
  3. Classifications
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    b. Vertebrates
  4. One-celled animals
  5. Needs of animals
    a. Water
    b. Food
    c. Oxygen
    d. Shelter
  6. Care of animals and their young
  7. Adaptations to environment
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    b. Homes
    c. Coats
    d. Protective coloration
    e. Hibernation
    f. Migration
  8. Defense mechanisms
  9. Helpful and harmful animals
  10. Genetic changes in animals
    a. Selective breeding
    b. Hybrids
    c. Natural changes
  11. Interdependence of animals and plants
    a. Balance of nature
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    d. Conservation
  12. Animals in agriculture

C. Plants
  1. Plants around us
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    c. Reproduction
    d. Uses
  2. Uses of plants
  3. Parts and functions of plants
    a. Roots
    b. Stems
    c. Leaves
    d. Flowers
    e. Fruits
    f. Seeds
  4. Classification of plants
  5. What plants need to live and grow
    a. Air

b. Water
c. Light
d. Proper temperature
e. Proper soil

6. Life processes of plants
a. Photosynthesis
b. Respiration
c. Transpiration
d. Reproduction
e. Tropisms

7. Reproducing plants
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b. Bulbs
c. Roots
d. Stems
e. Cuttings
f. Leaves

8. Genetic changes in plants
a. Selective breeding
b. Hybrids
c. Natural changes

9. Conservation

10. Plants in agriculture

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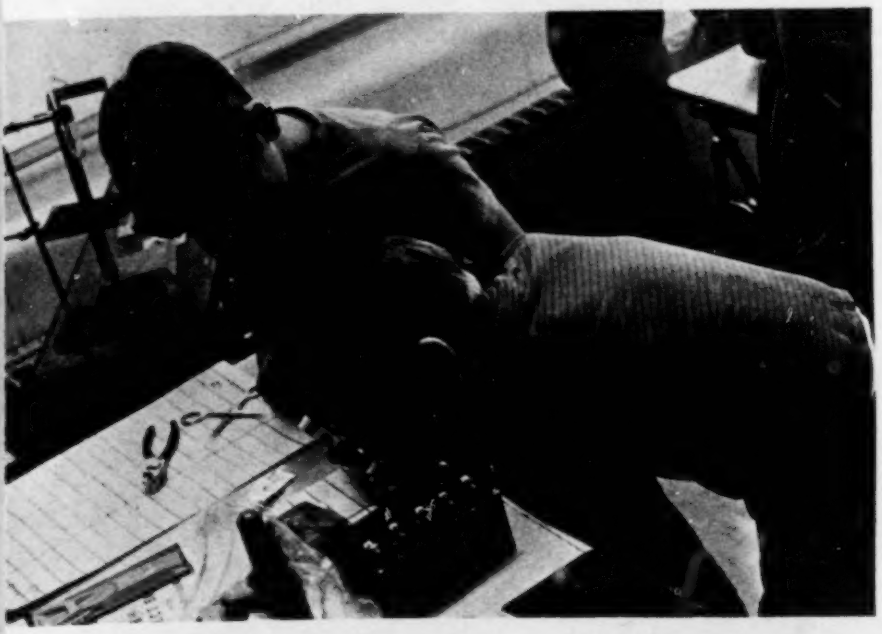
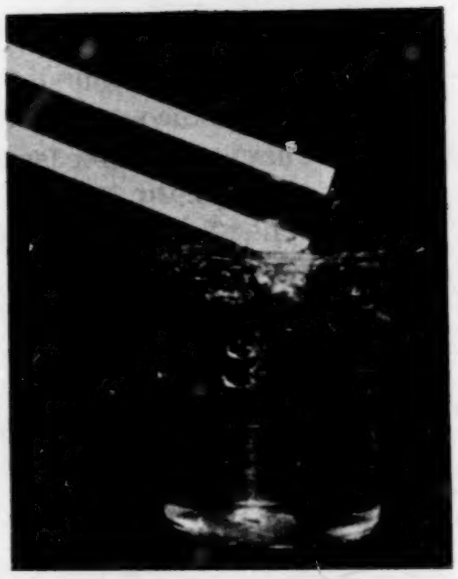
A. Matter
1. Kinds of matter
2. Common materials
3. Properties of matter
4. States of matter
5. Solutions
6. Crystals
7. Atomic structure
8. Elements
9. Molecules and atoms

B. Energy
1. Potential and kinetic





2. Forms of energy
3. Transformation of energy
4. Sources of energy
5. Relationship between matter and energy

C. Atomic energy
1. Nuclear structure
2. Nuclear radiation
3. Nuclear energy
4. Fission and fusion
5. Uses of atomic energy

D. Chemical energy
1. Chemical and physical change
2. Chemical changes in matter
3. Mixtures and compounds
4. Chemical symbols
5. Chemical formulas
6. Simple chemical equations
7. Common chemical compounds
a. Acids
b. Bases
c. Salts
d. Oxides
8. Oxidation
a. Slow and rapid
b. Rust
c. Flame and smoke
d. Conditions for making fire
e. Conditions for extinguishing fire
f. Fuels
g. Spontaneous combustion
h. Fire extinguishers
i. Fire safety

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- 3. Temperature measurements
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- 4. Heat transfer
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F. Wave energy

- 1. Wave properties
  - a. Reflection
  - b. Refraction
  - c. Interference
  - d. Diffraction
- 2. Light
  - a. Wave properties of light
  - b. Shadows
  - c. Transparent, translucent, reflecting and opaque materials
  - d. Particle properties of light
  - e. Visible, infrared, and ultraviolet light
  - f. Speed of light
  - g. Sources of light
  - h. Laws of reflection
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  - j. Laws of refraction
  - k. Lenses
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    - (2) Camera
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  - l. Spectrum
  - m. Colored lights
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- 3. Sound
  - a. Producing sound
  - b. Wave nature of sound
  - c. Transmission of sound waves
  - d. Speed of sound
  - e. Characteristics of sound
    - (1) Pitch
    - (2) Intensity
    - (3) Quality
  - f. Music
  - g. Musical instruments
  - h. Ear
  - i. Voice
  - j. Sound phenomena

G. Mechanical energy

- 1. Machines
  - a. Examples of machines
  - b. Simple machines
  - c. Compound machines
  - d. How machines help us
    - (1) Change force
    - (2) Change direction
    - (3) Change speed and displacement
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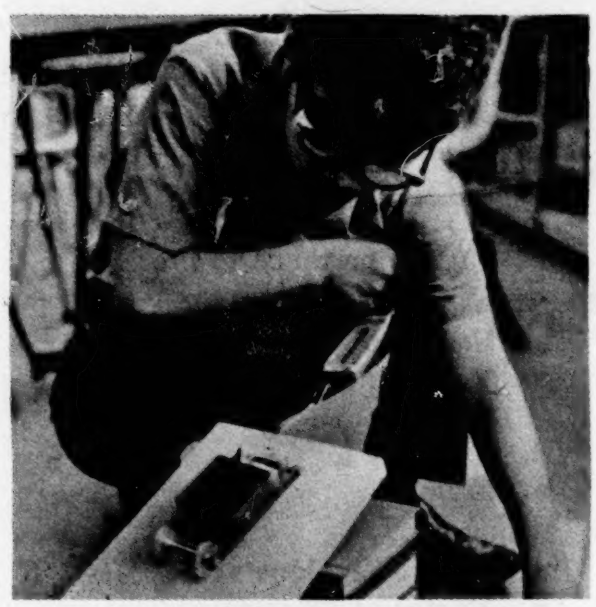
- 3. Mechanical advantage
- 4. Friction
- 5. Efficiency
- 6. Motion
  - a. Newton's laws of motion
  - b. Speed
  - c. Acceleration
- 7. Mechanics of fluids
  - a. Types and nature of fluids
  - b. Pascal's law
  - c. Bernoulli's principle
  - d. Flotation



H. Electrical energy
  1. Magnets
    a. Natural magnets
    b. Attraction and repulsion
    c. Magnetic fields
    d. Making magnets
    e. Electromagnets
    f. Compass
    g. Uses of magnets
  2. Static electricity
    a. Ways of producing static electricity
    b. Nature of static electricity
    c. Laws of electrostatic charge
  3. Current electricity
    a. Nature of current electricity
    b. Methods of producing electricity
    c. Series and parallel circuits
    d. Alternating current and direct current
    e. Conductors and nonconductors
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    g. Short circuits
    h. Electrochemistry
    i. Uses of electricity
    j. Electric motors
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    l. Communication devices
    m. Safety

IV. EARTH
  A. The earth
    1. History of the earth
    2. Land formations
    3. Water formations
    4. Earth's crust and layers
    5. Rocks
      a. Igneous
      b. Sedimentary
      c. Metamorphic
    6. Minerals
    7. Soil
      a. Formation
      b. Types
      c. Testing
      d. Enrichment
      e. Conservation
    8. Forces changing the earth
      a. Weathering — physical and chemical
      b. Erosion
      c. Earthquakes
      d. Volcanoes
      e. Works of man
    9. Soil and water
      a. Cultivation
      b. Irrigation
      c. Drainage
    10. Useful natural resources
      a. Coal
      b. Oil and gas
      c. Minerals
      d. Conservation
  B. The earth's atmosphere
    1. Air
      a. Properties of air
        (1) Air has weight
        (2) Air occupies space
      b. Where air is found
      c. Components of air
      d. Structure of the atmosphere
    2. Weather
      a. Differences between weather and climate
      b. Factors which determine climate

- (1) Basic factors
  - (a) Temperature
  - (b) Wind
  - (c) Humidity
- (2) Local factors
  - (a) Large bodies of water
  - (b) Ocean currents
  - (c) Winds
  - (d) Altitude
  - (e) Topography

- c. Kinds of weather
- d. How weather affects us
- e. Air masses
- f. Weather forecasting
- g. Water cycle
- h. Humidity
- i. Formation of precipitation
  - (1) Clouds
  - (2) Rain
  - (3) Snow
  - (4) Sleet
  - (5) Hail
  - (6) Dew
  - (7) Frost
  - (8) Fog

V. Space Beyond the Earth

- A. Solar system
  - 1. Sun
    - a. Nature of the sun
    - b. Distance to the sun
    - c. Position of the solar system
    - d. Source of energy
    - e. Effects on earth
      - (1) Heat and light
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  - 2. Moon
    - a. Nature of moon
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    - c. Phases
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  - 3. Planets
    - a. Nature of planets
    - b. Names of planets
  - 4. Comets
  - 5. Meteors and meteorites
  - 6. Universe
    - a. Stars
    - b. Constellations
    - c. Galaxies
    - d. Instruments for studying stars
- B. Space explorations
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  - 2. Satellites
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Behavioral Objectives

What do you want your students to be able to do after completing a science unit that they couldn't do before? It is not enough just to engage children in activities—they should be purposeful activities reflecting specific objectives.

If a curriculum project claims to have accomplished something, then one of the most fundamental obligations of the experimenter is to present evidence of change or proof of learning. But how can such proof be forthcoming unless there is initial agreement upon what the learner will "be able to do" after he has been exposed to the curriculum materials?

An instructional program of any kind, experimental or not, has the goal of establishing a particular set of behaviors. The learner is expected to be able to do something after completing the instruction that he could not do beforehand. In order to determine whether any change has actually occurred, it must be possible to observe or measure the post-learning behavior. Objectives stated in behavioral terms provide a method by which a teacher may recognize whether terminal goals have been accomplished.

The actual writing of behavioral objectives is not difficult but requires thought and knowing what is wanted. The process generally consists of three considerations: (1) the behavior desired, (2) a description of the situation, and (3) the extent to which the student should exhibit the behavior. The most effective behavioral objectives would contain all three criteria.

The behavior we expect to observe is indicated by some verb denoting action. We cannot observe knowing, understanding, appreciating, enjoying, believing or grasping the significance of. We can, however, observe a student who is constructing, identifying, demonstrating and naming.

Next, we must decide in what situation we are going to look for the behavior. If, for example, we expect students to identify constellations, then we should specify the situations in which the student will accomplish the task. Will the student work with photographs, simple drawings of the sky, separate drawings of each constellation, or direct observation at night? Also the extent to which the student should exhibit the behavior is important in evaluation, and it also helps guide the teacher in selecting content (what constellations) and determining the depth to which topics are to be studied.

The definitions of the action verbs used by Science—A Process Approach are as follows:

1. *Identify*. The individual selects a named or described object by pointing to it, touching it or picking it up.
2. *Name*. The individual specifies what an object, event or relationship is called.
3. *Order*. The individual arranges three or more objects or events in a sequence based on some stated property.
4. *Describe*. The individual states observable properties sufficient to identify an object, event, or relationship.
5. *Distinguish*. The individual selects an object or event from two or more which might be confused.
6. *Construct*. The individual makes a physical object, a drawing or a written or verbal statement (such as an inference, hypothesis or a test of any of these).
7. *Demonstrate*. The individual performs a sequence of operations necessary to carry out a specified performance.
8. *State a rule*. The individual communicates verbally or in writing, a relationship or principle that could be used to solve a problem or perform a task.
9. *Apply a rule*. The individual derives an answer to a problem by using a stated relationship or principle.

The above words are not necessarily the only words that can be used, but a group of seven to twelve words that are defined and used often are probably better than a longer list of twenty-five to thirty words or more. For example "pick up," "select," "hold," "identify," "point to" are action words that have a similar behavior. Why not use the one action word "identify" rather than all five. The same is true for the verb "construct" in objectives involving "design," "make," "formulate," or "build." It can be used whether the learner is constructing a statement or an object.

The following behavioral objectives have been written as a guide for teachers to write day-by-day or unit objectives:

Grades 1 - 3

A student should be able to...

...demonstrate with a ball or globe and a source of light why only half of the earth has daylight at any given time.

...name the plants whose leaves are used by man for food from a collection of pictures that the student has compiled of plants that man uses for food.

...place in order of size the following animals: mosquito, horse, dog, elephant, robin and butterfly.

...distinguish between living and non-living objects.

Grades 3 - 5

A student should be able to...

...state a rule about the attraction and repulsion of like and unlike poles of a magnet.

...demonstrate how the pitch of a vibrating string on a guitar can be varied.

...identify which of the following materials will conduct electricity: nail, rubber band, piece of glass, copper wire, toothpick, silver coin, metal piece from a tin can, paper, leather, wool cloth, aluminum foil, piece of plastic, piece of lead, penny and a piece of cardboard.

...construct or draw a system of pulleys where approximately 100 grams could lift 300 grams.

Grades 5 - 6

A student should be able to...

...demonstrate how the strength of an electromagnet can be varied, using an electromagnet that the student has constructed.

...apply a rule by calculating the work done in lifting a weight (in pounds) a certain number of feet.

...describe the characteristics of a group of animals called insects.

...distinguish between kinetic energy and potential energy by using an example.

Do behavioral objectives limit the outcomes of learning? It need not, if the objectives are well chosen, well stated and students are given freedom to branch out. Evaluation of student progress and the effectiveness of student activities can easily be determined. Teachers must be careful not to evaluate only the students' ability to recall isolated facts.

The behavioral objectives discussed so far apply mainly to the student gaining an understanding of the major concepts in science which Bloom categorized as the cognitive domain. There is another that concerns itself with critical thinking, attitudes and appreciations known as the affective domain. It is hoped that this area too may be evaluated through observation of special behaviors.

Inquiry Problems for Science Teaching

These inquiry problems are added to this curriculum guide to provide another technique of science teaching. These problems are presented in such a manner so that a child's mind will be challenged to inquire and hypothesize as to probable outcomes of the situation or reasons why the situation exists. With the hypotheses the child can then test or verify these in a testing situation or through collection of data on the situation. From this the child is able to draw a conclusion. More simply stated these problems are open-ended questions.

1. A paper cup is partially filled with water and is heated by a candle placed under it. Although the flame of the candle is directly below the cup, it does not burn.

   (Teacher's Note: The paper cup does not burn because as the water is heated in the cup it rises. Cold water then falls to the bottom to replace it. This process, called "convection of hot water rising and cold water falling," keeps the temperature at the bottom of the cup below the point where the paper would burn. When all the water boils away, the cup will burn.)
2. An ice cube is held in the lower part of a test tube by some steel wool that has been pushed into the tube just above it. The tube is almost filled with water. The water in the test tube is heated with a burner above the steel wool for some time. The ice cube, however, doesn't appear to melt.

   (Teacher's Note: Warm water rises and cold water falls or stays at the bottom. The water at the point where it is being heated is continually rising and being replaced by colder water from the surface. There is little circulation, however, between the colder water near the ice cube and the water heated above it, because cold water will not rise over warm water.)
3. Place three marbles in a groove on a board. Take another marble and slide it so that it hits the three marbles. One of the three marbles will move out as a result. Repeat the process, but hit the three marbles with two marbles at the same time. This time, two marbles will move away.
4. Place one ice cube in a container with alcohol and one ice cube in water. The ice cube in water will be at a different depth than the one in alcohol.
5. A shot-put and a tennis ball are dropped at the same time. They both land at the same time.

Unit—Seeds

FOREWORD

In this study of seeds, we have attempted to interest children to learn more about how plants begin to grow. It is our purpose in this unit to help children understand how seeds begin to grow, what they need to help them grow, how they travel, and how they are used. We have suggested questions to be used with each activity. These may be supplemented by the teacher if it is so desired.

For this sample unit of a long range plan, we wish to acknowledge our thanks to the students of Mayville State College who have shared it with us.

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SEEDS—Grade II

ACTIVITY I

Concept: Some plants grow from seeds. Some plants do not grow from seeds.

Purpose: To start a long range project from which children may learn through observation the ways in which seeds, bulbs and cuttings grow into plants.

PART I—PLANTING A SEED
(Long range experiment)

Concept: New plants may be grown from seeds.

Pre-class Preparation:

1. Secure a stalk of corn, including all the parts of the plant from the root to the ear of corn.
2. Have each child bring a milk carton and a packet of seeds from home. (See suggested seed list.)

In the Classroom:

1. Using the stalk of corn ask questions and have a discussion about the plant.
   (a) How did the plant (stalk of corn) begin to grow?
   (b) What part of the plant looks like the seed that was planted?
   (c) What did the plant need so that it could grow?
   (d) In what kind of soil did the plant grow?
   (e) Make a list of new words such as, seed, parent plant, sunshine, soil, garden soil, etc. New words may be added to the list as the activity proceeds.
2. Have each child plant three seeds in his milk carton. Be sure that the seeds are spaced correctly and planted deep enough in the soil. See directions on seed packet.
3. Discuss taking care of the plant. Each child should take care of his own plant.
4. Staple a tag to each box with the following: Child's name, kind of seed, date of planting.

Equipment:

A stalk of corn
Milk carton and packet of seeds brought from home, one per child
Tags made from tagboard, one per child
Stapler
A pail of garden soil

References:

How a Seed Grows, Illus. by Joseph Law; Crowell Co. 1960. 201 Park Ave. S. New York, N. Y. 10019

Seeds and More Seeds. Pictures by Tomi Ungerer; Harper and Row Co. 43E 33rd St. New York, N. Y., 10016

An Elementary Science Source Book. Vol. I, Dept. of Instruction, Bismarck, N. Dak.

Suggested Seed List:

Avocado
Orange
Grapefruit
Pumpkin
Lettuce
Bean
Pea
Zinnia
Marigold
Carrot
Cucumber
Radishes
Corn
Tomato

Long Range Experiment:

Child may keep a record as:

1. Counting days from planting until plant emerged.
2. After plant has emerged measuring how tall the plant grows from week to week. (May use a strip of tagboard. Mark it, use metric system to measure.)

3. Notice how the plants are alike. Ask, "Why?"

PART II—PLANTING A BULB

Concept: New plants may grow from bulbs. (Long range experiment)

Pre-class Preparation:

Secure a bulb that has begun to sprout.

In the Classroom:

1. Discuss that there is another way to start a new plant to grow. It is done by planting the bulb in soil. Ask, "Why do we plant the bulb in the soil?"
2. Place the sprouted bulb in the soil and cover it with soil.
3. List new words such as, bulb, sprout, emerge, and care.
4. Discuss again what a plant needs in order to grow.
5. Label the box: BULB—ONION—DATE.
6. Choose someone to care for the bulb.

References:

Life Series. Book 2, the Macmillan Co., New York, N. Y.

Long Range Experiment:

1. Children may examine the bulb and see how many days it takes before the new plant emerges.
2. After plant has emerged measure the height from week to week.

PART III—PLANTING A CUTTING

Concept: New plants may be grown from cuttings (Long range experiment)

Pre-class Preparation:

Secure a plant such as a geranium, coleus, begonia or ivy.

In the Classroom:

1. Discuss that there is another way to start a new plant to grow. It is done by taking a "cutting" from the parent plant. The cutting is put in a glass of water. Leave it there until you can see small root hairs. Ask, "Why is it called a 'cutting'?"
2. Explain that after it has roots it needs to be planted in soil. Ask, "Why does it need soil?"
3. Add new words to the list such as, cutting, and geranium.
4. The glass may be labeled: CUTTING—GERANIUM—DATE.
5. The children may examine the cutting from time to time to see if the roots are beginning to grow.
6. When the roots have been developed, plant the cutting in a pot of soil. Ask, "What does the plant need to help it grow?"
7. Choose someone to care for the plant.
8. The parent plant and new plant may be compared. Ask, "Why are the two plants alike?"

Equipment:

A potted geranium or other plant
A glass of water
A sharp knife
A pot with soil
A label and tape

References:

Life Series. Book 2, the Macmillan Co., New York, N. Y.

PART IV—SEEING HOW PARTS OF A PLANT GROW

Concept: A new plant grows roots, stems and leaves. The roots grow downward, the stem and leaves grow upward. (Long range experiment)

In the Classroom:

1. Ask for volunteers who would like to use their own plant for this experiment.
2. By this time the children will probably know the different parts of the plant.
3. Ask them to name the parts they see above the soil.
4. Ask, "What part of the plant is below the soil?"
5. Let children remove the plant carefully so that the roots won't be broken.
6. Have them display the plant on a white

sheet of paper. Tape the paper to the blackboard and tape the plant to the paper.

7. They may label the parts of the plant on the paper.
8. This may be a good time to show the film, "Life Story of a Plant."

Equipment:

Plants that are grown tall enough to see the roots, stems and leaves

White paper

Tape

A stick to help remove the plant from the pot

Film

References:

Life Series. Book 2, the Macmillan Co. New York, N. Y.

Film: "Life Story of a Plant"

ACTIVITY II

Concept: Inside the seed is a baby plant.

Purpose: To provide the children with an opportunity to discover the contents of a seed.

PART I

Pre-class Preparation:

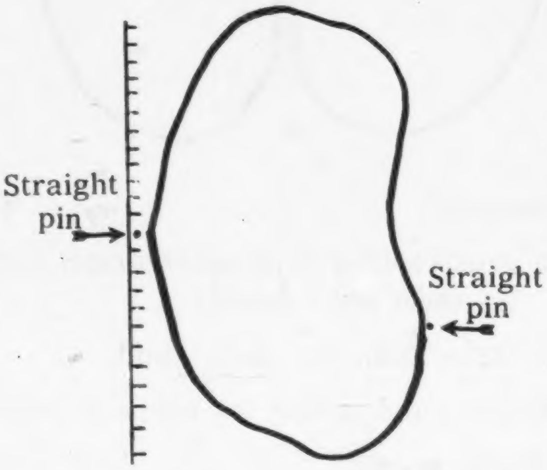
The children may discover that the seed is covered entirely by a *seed coat*. On the curved edges, a *scar* may be found. This is where this seed was attached to the pod. The scar is called the *hilum*. On the seed coat there is also a tiny hole where the pollen tube that fertilized the seed entered. This is called the *micropyle*.

Underneath the seed coat, which slips off easily, are two large cotyledons. These are rich in stored food.

In the Classroom:

1. Divide the class into teams of two.
2. Have each team measure one bean by placing it on graph paper. The graph paper could be placed on the backs of the students tablets so the pins will stick.

Place the first pin into the graph paper on the dark line. Lay the bean next to it. Now place the pin on the opposite side of the bean as close as possible. Do this for width and length of the bean. Put a pencil mark where the pins have been. Have the children count the number of lines between pin points. This will show measurement in centimeters. Collect these papers.



3. Ask how the bean looks? Note that it is smooth and firm. What do they think is inside?
4. Now the measured bean which has been marked by ink and another bean will be placed in paper cups. Cover the beans with water. Let soak overnight. Paper cup must be labeled.

PART II

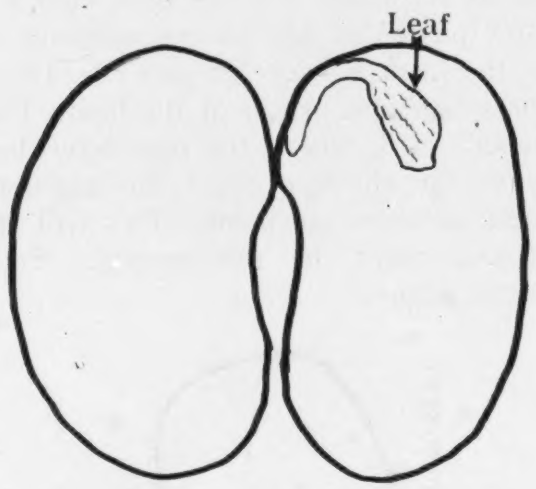
In the Classroom:

1. After paper towels have been distributed, place bean on graph paper and measure as was suggested for the first

day. Have the children note the difference in size. "Why is the bean larger?" "How does the bean look today?"

2. Have students remove the seed coat. Next have each child pin his bean carefully. (Some may need help.) Have student notice the two cotyledons. Each child should recognize the embryo inside the bean. Have them identify the root and two small leaves.

3. Use a hand lens to see veination in tiny leaves. "What is the color of this plant? What color will it be when sunlight begins to shine on it? Now what is inside a seed?"



Equipment:

5 squares to a centimeter graph paper. (1/4 sheet per 2 pupils)

A lima bean for each child.

Paper cups — one for every 2 children

Paper towels

Straight pins — 2 for each team of 2 children

Hand lens (2X or 4X magnification) — one for each team

References:

World Book Encyclopedia. "Seeds"

Laidlaw Science Series, *Science* 2. Smith, Blecha, Sternig.

Thinking about Science. Lyons and Carnahan.

ACTIVITY III

Concept. A plant may need (1) water, (2) soil, (3) sunlight, and (4) correct temperature to grow.

Purpose. To help boys and girls understand that when the proper conditions are present, seeds will start to grow.

PART I

Concept. A plant may need water to grow.

Purpose. To help boys and girls understand that plants may need water to grow, to promote the ability to anticipate outcomes, to lead them to discover part of the answer to the question, what do plants need to grow?

Pre-class Preparation.

Get materials ready for the experiment.

In the Classroom.

1. Tell the children that in order for a plant to grow it may need several things. The title question — What do plants need to grow? — should be raised. Try to motivate the children to find the answer.

2. Since there are four parts to this activity, divide the class into four groups and each group will perform one part of the activity. The experiments will be done as a class experiment instead of individually or in small groups. The experiments can be presented as demonstrations.

3. Lead children to understand by experimentation that plants and seeds may need water in order to grow.

4. Have the members of the first group get the materials ready that they will need. Have them follow directions by wetting the paper towels and inserting them in two glasses, putting a dry paper towel in the third glass and putting the seeds in place between the glass and paper. Then put water in two of the glasses. Put all the glasses in a warm, sunny place.

5. Lead a short discussion on the experiment. "Will all the seeds in our glasses get sunshine? What did the seeds in two of the glasses get that those in the other glass did not? What do you think is going

to happen?" Note development of ability to anticipate outcomes.

6. This will take several days or possibly a week or two. It can be the responsibility of the first group to water the same two glasses every day. At the beginning of each science period have the group show the class so that they can observe what is happening.
7. Summarize the concept that a plant may need water to grow. After the results are evident ask the questions concerning this concept — Is sunshine enough to start seeds growing? How do you know? What happens to the seeds that get water? What happens to the seeds that do not get water?
8. Now water one glass of plants every day. Do not water the other one. (These are the two plants that received water previously.) "What happens to the plants that are watered? What happens to the plants that are not watered? Do plants and seeds need water to grow?"

Equipment:

6 sunflower or other seeds
3 glasses (clear)
water in a pitcher or a container
paper towels

PART II

Concept: A plant may need soil to grow.

Purpose: To help children understand that plants may need soil in order to grow, to promote ability to compare and contrast.

Pre-class Preparation:

1. Get materials ready for the experiment.
2. Plan for a field trip to investigate types of plants that grow in different soils. Get permission from parents and school. Also arrange for transportation if it is needed.

In the Classroom:

1. Help the class recall the experiments they did in the preceding lesson.
2. Observe the plants from the experiment showing that plants may need water to grow.
3. Raise the question, "Do plants need anything besides water to make them grow?" Today we are going to experiment to see if they do.
4. Lead pupils to discover through experimentation that plants may need soil to grow. Write on the board, "Do plants and seeds need soil?" Encourage the children to answer it to the best of their knowledge at the present time. Record their reasons and compare them to what they find out as they study and perform the experiment.
5. At this time call on the second group to perform this experiment. Put some stones in a glass jar (about ½ full). Put one lima bean seed in a pan of soil and another seed in the jar of stones (stand the seed on end). Put water in the jar of stones until it covers part of the seed. Also water the seed in the pan of soil.
6. Now lead a discussion about this experiment. "Do you think the seed in the jar of stones would grow if we covered it completely with water? Why didn't the seeds grow in a glass that was full of water? (They could not get any air.) What are both of our seeds getting? (Water) What is different about the way we are treating the two seeds? (One is planted in soil and one in stones.) What do you think is going to happen to each of the two seeds in this experiment?"
7. This experiment will take three weeks before the results are rather evident. Observe the plants each week. Ask the questions: Which plant looks stronger? What did each of these plants use for food when it first began to grow? When the food stored in the seed was used up, did either one of these plants get any more? How can you tell? Where do you think it found food? Why can't the other plant get food from the stones? They are too hard. How long do you think the plant in the jar of stones will live without food?

   Let's water our plants and watch them grow to see. Mark the calendar.
8. Use the question "Do plants and seeds need soil?" to summarize the lesson.
9. The boys and girls should experiment

to see in what kind of soil cactus and other plants grow best.

10. Take children on field trips to see what kind of plants grow best in sandy soil; in clay; and in black crumbly soil. Bring back soil samples and a specimen of each of several kinds of plants that grow best in each kind of soil. Prepare and exhibit. If a field trip is not possible it can be an assignment to be done at home.

Equipment:

2 seeds (lima bean)
pan or box of soil
glass about ½ full of stones
water
blackboard
calendar

PART III

Concept: A plant may need sunlight to grow.

Purpose: To help boys and girls understand that plants may need sunlight to grow, to develop the ability to compare and contrast.

Pre-class Preparation:

Get ready the materials for the experiment.

In the Classroom:

1. Lead the children to state the problem they have been working on for several lessons: "What do plants need to grow?" Have them tell what they have found out so far. Prepare them to experiment further. Ask, how the previous experiments have helped us in finding out what plants need to grow.
2. Write on the blackboard: WHAT DO PLANTS NEED TO GROW? "Who can tell us what we have learned that plants need to grow?" As the children name them, write on the board: WATER, SOIL. "Do you suppose plants need anything else to help them grow?" Today's experiment will help us find out.
3. Lead the class to understand through experimentation that plants may need sunlight in order to grow. "What else do you suppose plants need to help them grow?"
4. At this time call on the third group to perform the experiment. Have them plant 3 lima bean seedlings or other plants each in a separate pot of soil. The plants used should all be of the same kind, however. Put one plant where it can get the maximum amount of sunlight; put the second plant in a dimly lighted place; place the third in a dark closet or under a box. Water all three twice a week.
5. Observe these for two weeks. Then ask questions: How have the plants that were kept in the dark changed in color? How have their leaves changed? Now let's look at the other boxes.
6. Tell how they have changed. In what ways does a plant grown in sunlight look different from one grown in dim light and one that was grown in the dark?
7. Use the question — Do plants need sunlight — to summarize the lesson.

Equipment:

3 lima bean seedlings or other seeds all of the same kind
soil
water
3 pots (as a cottage cheese carton)
dark closet or box
a place with maximum sunlight
a dimly lighted area

PART IV

Concept: A plant may need the correct temperature to grow.

Purpose: To help children understand the relation of temperature to plant growth.

Pre-class Preparation:

1. Get materials ready for the experiment.
2. Have an experience chart paper and marker ready for summarizing this activity.

In the Classroom:

1. Review what children have learned about things plants need to grow (water, soil, sunlight). Raise the question: Do plants need anything besides water, soil, and

sunlight to grow? Write some incomplete sentences on the board about plants. Write: ONE THING A PLANT NEEDS IS ———. After the boys and girls have read it and completed it orally, write their answer in the blank. Continue in the same way with sentences such as, PLANTS WILL NOT GROW IF THEY DO NOT HAVE ———. ——— IS ANOTHER THING PLANTS NEED TO MAKE THEM GROW. Comment, "Plants need something else to make them grow. Let's find out what it is."

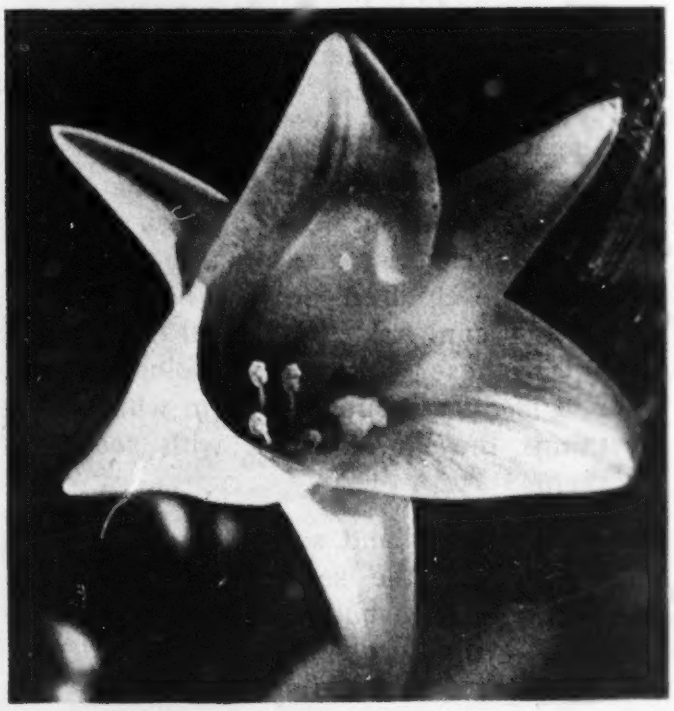
2. Lead the class to study and perform the experiment to see if an African violet (or two other identical potted plants) needs a warm place to grow. The children should give both plants water and sunlight. Put one plant outdoors if it is cold (or put it in the refrigerator). Leave the other plant in a warm, sunny room. "How are the plants treated alike? In what way did they treat them differently? What are they trying to find out by doing this experiment?"
3. Water the plants regularly and observe any changes.
4. After three weeks, look at the plants. "What has happened? Why do you think one of them has died?" Also place a thermometer near each plant and observe the temperature.
5. Summarize what the class has learned about the effects of temperature on the growing of plants. Review the idea that the boys and girls treated both of their plants just alike except in one respect (temperature). Inquire, "What did we find out from the experiment in this lesson? Why did we use two plants of the same kind? Why will we give both plants water, soil, and sunlight? If we do not water the plant we put in a cold place, and it dies, can we say it died because it was in a cold place? Why?" Continue to review in the same way other experiments.
6. Apply their findings to everyday situations. Ask, "In the fall, if the weather gets cooler, why do we bring geraniums and various other plants into the house? Why do we cover some plants at night if the weather report is for low temperature?"
7. Summarize the activity on "What do plants need to grow?" First observe plants or seeds from each of the four experiments. On the top of an experience chart write WHAT DO PLANTS NEED TO GROW? Then lead the children to review the results of the experiments. Have them give sentences of things that they have learned in this activity and also answering the question at the top of the chart. Make them simple sentences, but including any new words they have learned in the activity.
8. Ask if anyone has any questions on the experiment.
9. Read the experience chart as a review of the activity.

Equipment:

2 African violet plants (or two other identical potted plants)
water
2 thermometers
blackboard
experience chart
marker
a refrigerator if a cold place is not available outside.

References:

Teacher's guidebook for *Science Is Learning*. Marshall, J. Stanley and Beauchamp, Wilbur L. Scott, Foresman and Co.



ACTIVITY IV

Concept: Seeds are produced by many plants.

Purpose: To help children perceive sequential relationships involved in a plant's life cycle and that it passes through a definite cycle from seed to seed.

PART I

Concept: It seems that many plants need flowers to get seeds.

Purpose: To help children understand that in order for some plants to get seeds they must first grow flowers.

Pre-class Preparation:

1. Have ready a tomato plant to be planted for the children to observe.
2. Plan a bulletin board or exhibit showing the flower, seed, and fruit, if there is any, of various plants.
3. Bring several kinds of seeds and bulbs to class of various flowers and fruits and illustrations (pictures) of each.

In the Classroom:

1. Help the class recall that many plants grow flowers in order to get seeds.
2. Arouse interest in seeing the seeds different kinds of flowers make. Ask: What kinds of seeds have you seen? Where do many seeds come from in the beginning? (Flowers make them.) Do you think you could find any seeds in a vegetable garden?
3. Show pictures of flowers such as a rose, tulip, sweet pea, marigold, and fruits such as oranges, apples, grapes, peaches, cherries, and the seeds of each. Have the children identify them as well as they can. Ask. "Have you ever eaten any of these?" Have them point to them and identify them. Ask them what other things they have eaten with seeds in them.
4. After flowers and seeds have been discussed, put the seeds in a cellophane folder. Make a bulletin board display by pinning the seeds with a picture of the flower or fruit and label each one.
5. Plant a tomato plant as a demonstration for the class. Watch the tomato plant grow and bloom. Watch the flower dry and fall from the plant. You can see a tiny tomato begin to grow. The tiny tomato will grow and grow on the tomato plant. Then it will begin to change in other ways. The fruit will be getting ripe.
6. Ask the children what other plants they know grow and produce flowers in this way, and discuss the cycle they go through.
7. Give every 2 students a magnifying glass and have them look at the various seeds to see how they are different. Do the flowers look different? Do different kinds of flowers make different kinds of seed? In what ways are seeds similar?

Equipment:

Tomato Plant
Soil
Water
Bulletin board
Pictures of flowers and fruits
Seeds or bulbs to go with each illustration
Cellophane to put the seeds in for display
Labels for each illustration
Magnifying glasses per 2 students

PART II

Concept: Seeds and fruits may grow from flowers.

Purpose: To introduce the scientific meaning of fruit; to help children understand part-whole relationships involved in the production of fruit and seeds.

Pre-class Preparation:

1. Bring several fruits to class such as apples, oranges, bananas, grapes, cherries, peaches, tomatoes, cucumbers, beans or whatever is possible to obtain.
2. Bring several kinds of nuts in their shell.
3. Bring a few kinds of grains like, oats, corn and wheat, in their husks. For samples of grains, the State Mill and Elevator will send free of charge samples of grains. (See reference)

In the Classroom:

1. Fruits grow from flowers too. Fruits are seed coverings. The seeds are in the fruits.

2. Have an apple, orange, tomato, grape, peach and other fruits lying on a table. Ask if anyone knows a name for such things. (Fruits) "Do they all have seeds in them?"

3. Many fleshy fruits of plants have the seeds inside. Let the children cut the fruits open to find the seeds and to see how they are placed inside the fruits. Seeds from different kinds of fruits are not alike. Seeds from the same kind of fruit are very much alike. Help the children to develop those generalizations by asking questions such as, "Is the tomato seed like the apple seed or orange seed? Is the apple seed like the orange seed? Are apple seeds from different apples almost alike?" Take seeds from several tomatoes or oranges or apples or other fruits and then ask, "Can you tell which tomato this seed came from?", etc. They cannot, of course.

4. The seeds of tomatoes, apples, and oranges are alike in that they all grow inside the fruit. Many other fruits should be brought and examined for seeds. Such fruits as strawberries have seeds growing on the outside.

5. Again, if it is desired, have the students examine the different seeds of fruits with magnifying glasses.

6. Show several kinds of nuts and grains in their husks. Ask, "Are all these seed coverings alike? How are they different? (Some, like the shells of the nuts, are hard and tough. The husks of the grain seeds are papery and thin.) Are these things fruit? Why do you think so?" Crack open the nuts and take off the husks of the grain to show that there are seeds inside. "How are these fruits different from the others like the oranges and apples?" (Their coverings are thick and juicy.)

7. Display the nuts and inquire, "Who knows another name for these fruits?" Do the same for the grains. Comment, we often use another name for such fruits as sweet peppers, pumpkins, potatoes, carrots, beets and radishes; who knows what it is? (Vegetables)

8. Have the class make a list of the different kinds of fruits they have eaten or know about. Be sure they tell how they know each one is a fruit. This could be done using an experience chart. Guide them to include nuts, grains, berries and vegetables, as well as oranges and plums. Ask, "Where do fruits come from? What is inside a fruit?"

9. Have the boys and girls make an exhibit of different kinds of fruits. They should classify them as, nuts, grains, vegetables, and other fruits. Label each one.

Equipment:

Fruits such as apples, oranges, bananas, grapes, cherries, peaches, beans, tomatoes, etc.
Knife
Magnifying glasses per 2 students
Several kinds of nuts
Several kinds of grain in their husks
Chalkboard or experience chart

References:

The New Seeing Why. Grade 2, Dowling, Thomas; Freeman, Kenneth; Lacy, Nan; and Tippett, James. John C. Winston Co. 1957.

Science Is Learning. Grade 2, Marshall, J. Stanley and Beauchamp, Wilbur L. Scott, Foresman and Co. 1965.

Searching in Science. Grade 2, Jacobson, W. J. Lauby, Cecelia and Koniceh, Richard D. American Book Company, 1965

North Dakota Mill and Elevator, P. O. Box 1078, Grand Forks, North Dakota 58201

Additional Activities:

A field trip could be taken to a vegetable garden or a store and visit the department with fruits, nuts, vegetables.

A visit could be made to the flour mill.

The students could make a scrapbook of the plants that they know.

Read them a story on seeds, flowers, or fruits.

To correlate with art, they could make a picture with seeds like the diagram on the following page. Other seeds may be substituted for those suggested.

ACTIVITY V

Concept: Seeds travel in many ways.

Purpose: To help children discover the variety of ways in which seeds are scattered.

PART I

Purpose: To have the children find seeds and bring them to class for study. Use a field trip.

Pre-class Preparation:

1. Get permission from owner of garden or plot of ground that you wish to explore.
2. Prepare a list of things you wish to explore and notice on your trip.

In the Classroom:

1. Have a discussion with children before leaving school and also while exploring. Example:
   (a) Find out from children from past experiences what they know about seeds and parent plants.
   (b) Ask questions as: Where can we find plants with seeds on them? How are seeds moved about? Do animals and birds like seeds? Why? What do they do with seeds?
2. Divide the class into teams of two.
3. Explain that they are to collect seeds and place them in the bags provided.
4. Appoint two children to pull the woolen cloths through patches containing plants with seeds.

Equipment:

Medium sized bags, one per two children
Two pieces of woolen cloth with string tied to the corner
Two extra bags for the woolen cloths

On the Field Trip:

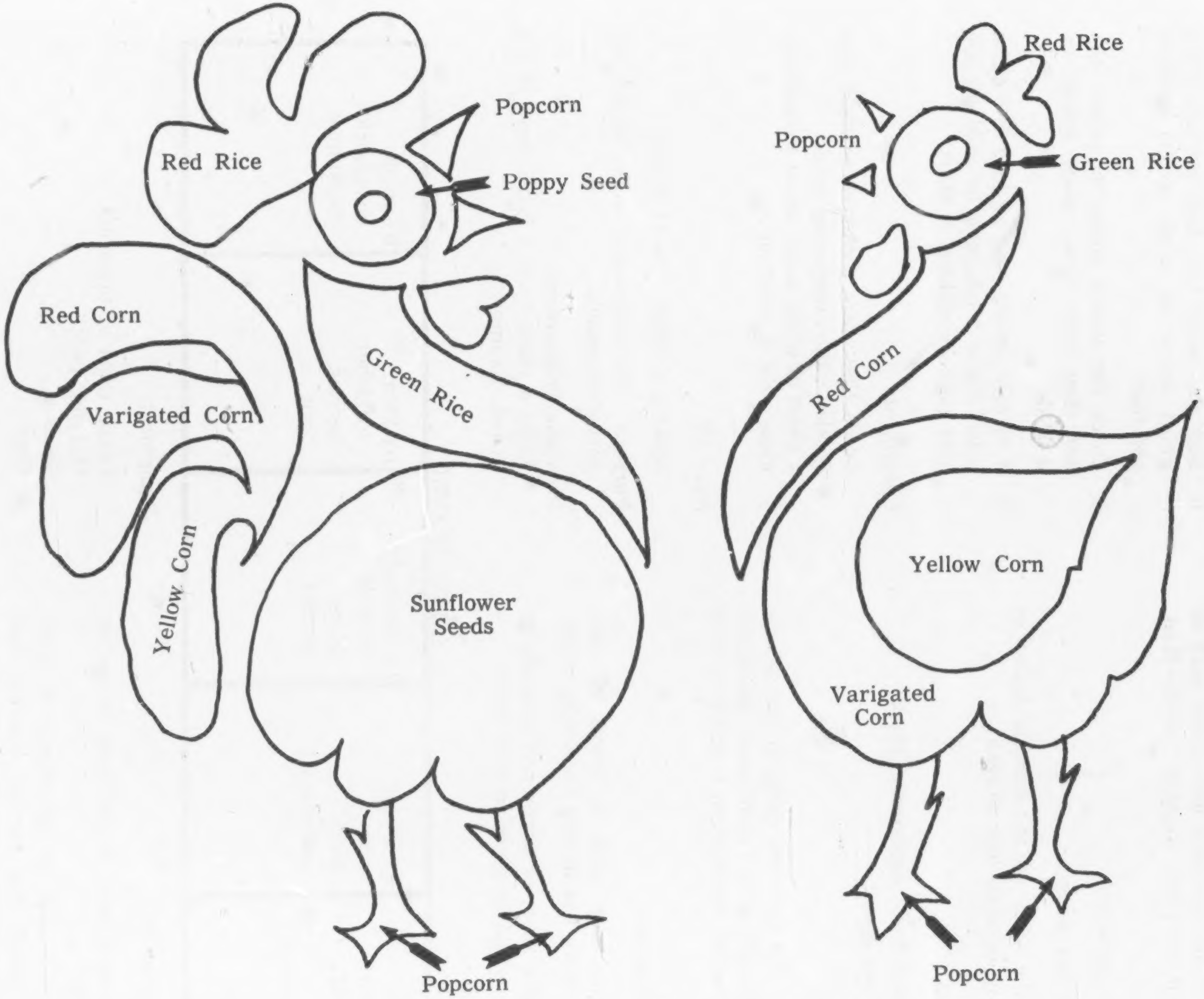
1. Notice where seeds have traveled as you walk along. Probably some seeds have fallen between cracks in sidewalks and are growing.
2. As you walk by trees, stop and have children discover the seeds.
3. When visiting the garden find the seeds in pea and bean pods. If there are cucumbers and tomatoes, samples might be picked and used in classroom later.
4. Notice the fall flowers. Pick some, such as the Aster, Marigold, Zinnia, etc.
5. From bushes find where the seeds are and take samples such as the rose.
6. Find a vacant lot or patch where plants with seeds are abundant. Have the woolen cloths dragged through the plants. Place them in bags.
7. Try to find a place where it has been "marshy" and find seeds that grow there, especially the cattail. Some dandelions also may be available.
8. Watch for small animals who are probably moving or eating seeds.
9. Try to find unusual places where seeds may have fallen such as water spouts, tree stumps, etc.

Equipment:

Medium sized paper bags, one per two children
Two pieces of woolen cloth with string tied to the corner
Two extra bags for the woolen cloths

PART II

Purpose: To organize children's first-hand evidence. (Do this as soon as possible after the field trip. This may be done


Red Rice
Popcorn
Poppy Seed
Red Corn
Varigated Corn
Yellow Corn
Green Rice
Sunflower Seeds
Popcorn
Red Rice
Popcorn
Green Rice
Red Corn
Yellow Corn
Varigated Corn
Popcorn

HEN AND ROOSTER SEED PICTURE DESIGN

in correlation with reading or story-telling time.) Use an experience chart.

In the Classroom:

1. Direct the discussion by asking questions.
2. Try to include some new words such as habitat, meadow, scatter, travel, float, etc.
3. Write the story.
4. Read the story.
5. Put the story on the bulletin board so it may be seen and re-read.

Equipment:

1 sheet from experience chart
Marking pencil

PART III

Purpose: To have the children look at the seeds and notice the different characteristics which cause them to travel as they do.

In the Classroom:

1. Children may work in teams of two. Each team has its bag containing seeds.
2. A white sheet of paper and magnifying glass should be given to each team.
3. Seeds may be poured onto white paper or sheet.
4. Direct an open discussion of how certain seeds travel. Examine seeds and see why they travel as they do.
5. Sort the seeds into four groups; those which travel by wind, water, animals and man.
6. Check the woolen cloths for seeds. Ask why they think these seeds travel as they do?
7. A further sorting may be done on a clean table. These seeds may be used for the next part in making a chart.

Equipment:

Seeds that were gathered on field trip
Woolen cloths contaning seeds
1 sheet of white paper and a magnifying glass, per 2 children

PART IV

Making a chart, "Seeds Travel"

Purpose: To record and organize the observations made.

Pre-class Preparation:
Make a chart from a large sheet of tag board. Example:

SEEDS TRAVEL

By Wind:	By Water:	By Animals:	By Man:	By Birds:
dandelion milkweed cattail tumble weed poplar ash elm	elm birch cottonwood	cocklebur acorn berries	cocklebur berries fruit	honeysuckle red sumac

In the Classroom:

1. Seeds have been sorted from preceding activity.
2. Give each child an opportunity to paste seeds under the correct heading and giving the name of the seed. (The teacher may check to see that they are correct.)
3. The chart should be posted where children are able to paste on more seeds when they find different seeds.

Equipment:

Large sheet of tagboard
Marking pencil
Seeds
Glue

Follow Up: Interest in seed dispersal continues throughout the year. Encourage the children to bring to school new kinds of seeds that they have discovered. Suggest places where seeds may be found such as in the garden, in trees, in vacant lots, ponds, in food and simply everywhere around them.

Suggested List of Seeds:

"Hitch-hiking" seeds:
  Burdock
  Tumbleweed
  Thistle
  Cocklebur

Seeds eaten by birds:
  Honeysuckle
  Dogwood
  Red sumac

Seeds moved by animals:
  Grain
  Acorns

Winged Seeds:
  Ash
  Elm
  Birch

Seeds from fruit:
  Orange
  Apple
  Peach
  Pear
  Plum
  Cherry
  Melons
  Tomatoes

Airborne:
  Cottonwood
  Milkweed
  Cattail
  Dandelion
  Aster
  Goldenrod

Unusual Seed:
  Cocoanut (may hold record for distance traveled)

Books:

Today's Basic Science. Navarra Zafforoni, Harper and Row, 1967.

Seeds and Seed Travels. Bertha Parker, Harper and Row, 1941.

An Elementary Science Source Book. Vol. I, Dept. of Public Inst. Bismarck.

Films:

"Seed Dispersal" and "Life in a Vacant Lot"

ACTIVITY VI

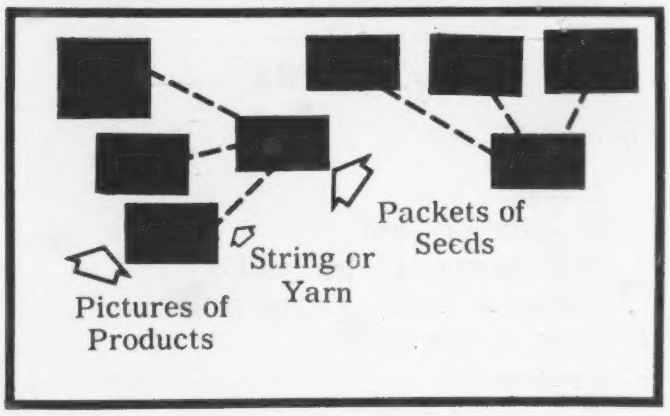
Concept: Seeds are used in many ways.
  1. Man uses seeds.
  2. Animals use seeds.

Purpose: To help students understand how important seeds are to our diets. To help students to understand how important seeds are to animals.

PART I

In the Classroom:

1. Begin the classroom discussions by asking the students to name the seeds they ate for breakfast that morning.
2. What foods do we eat that are made from wheat flour? (Cake, bread, cereal, pancakes)
3. What foods are made from dried corn that we eat? (Muffins, corn flakes, corn bread, etc.)
4. In what food do we eat oat seeds? (Oatmeal, oatmeal cookies)
5. You may use a mortar and pestle to make flour from a few wheat grain seeds. Discuss how the Indians made their flour this way. Primitive people in India and in Africa still do this.
6. Seeds that man eats can be brought out by discussion. Some suggestions are green beans, nuts, peas, lima beans, navy beans, corn, rice, wheat, oats, rye, millet, buckwheat, sunflowers, poppies, dill.
7. A bulletin board should be prepared of the seeds with corresponding pictures of their finished products.



PART II

In the Classroom:

1. Start the discussion by asking if the children can tell if their pets eat seeds. (Parakeets eat millet seeds, grains and bird seed.) It can be discussed that dogs and cats do not prefer grains in their original state. Cats and dogs will eat bread, and other grains after they have been processed. Hamsters, white mice may be other pets they will have.
2. The next type of animals that can be discussed are the ordinary farm animals such as cows, horses, pigs, geese, ducks, chickens, goats. They eat corn, oats, barley and screenings—that is an assortment of seeds from weeds in the fields.

3. The last kind of animals to be discussed will be the wild animals that are found around North Dakota fields. Squirrels, chipmunks (nuts, acorns, seeds of grasses, and apple seeds are their common seeds), gophers, mice, rats, rabbits, and deer (all these eat grains) are some of the wild animals found in North Dakota fields.
4. Have each child draw a picture of their pet and the seed that their pets will eat. This may be correlated with art class.

Equipment

A mortar and pestle
Some wheat seeds
Samples of grains that may be put in plastic bags such as wheat seed, oat seed, barley seed, corn seed, sunflower seed, poppy seed, etc.
Pictures of finished products to correspond to the seeds used.
A piece of drawing paper for each child.

APPENDIX

Equipment

Stapler
A stalk of corn
Milk carton (1 per child)
Packet of seeds (1 per child)
Tags (1 per child)
Garden soil
A sprouted bulb
A milk carton filled with soil
Tags or labels
A potted geranium or other plant
A glass of water
A sharp knife
Plants which root, stem and leaves are evident
White paper (1 per child)
Centimeter graph paper (1 sheet per 8 children)
Lima Beans (1 per child)
Paper cups (1 per 2 children)
Paper towels
Straight pins (2 per team of 2 children)
Hand lens (2x or 4x magnification) (1 per team)
6 sunflower seeds or other seeds
3 glasses (clear)
Glass about ½ full of stones
Blackboard
Calendar
Dark closet or box
A place with maximum sunlight
A dimly lighted area
2 African violet plants (or 2 other identical potted plants)
2 thermometers
Experience chart paper
Marker
A refrigerator if a cold place is not available outside
1 tomato plant
Bulletin board
Pictures of flowers and fruit
Seeds or bulbs to go with each picture
Cellophane to put the seeds in for display
Labels for each picture
Fruits as apple, orange, bananas, cherries, grapes, peaches, etc.
Several kinds of nuts
Several kinds of grains in their husks
Medium sized bags (1 per 2 children)
Two pieces of woolen cloth with string tied to the corner
Two extra bags for the woolen cloths
1 sheet of white paper (1 per 2 children)
Large sheet of tagboard
Seeds
Glue
A mortar and pestle
Some wheat seeds
Samples of grains to be put in plastic bags
Pictures of finished products to correspond with seeds used
A piece of drawing paper for each child
5 pots or pails of garden soil
5 pitchers or containers of water
5 lima beans

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ADDITIONAL REFERENCES

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Seeds and Seed Travels, Parker, B. M.; Harper and Row.

Garden Indoors, Parker, B. M.; Harper and Row.

The Garden and Its Friends, Parker, B. M.; Harper and Row.

The Plant World, Parker, B. M., and Podendorf; Harper and Row.

How a Seed Grows, by Jordon, Helene, Jr.; Crowell Co.

Seeds and More Seeds, pictures by Toni Ungerer. Harper and Row.

What's Inside of Plants?, Zim, Herbert S., Marrow.

FILMS

Life Story of a Plant
Seed Dispersal
Life in a Vacant Lot

Contract Approach-Friction

To keep with the theme of this curriculum guide this sample unit is included to demonstrate the organization of the contract approach to teaching. This is one approach and many other variations are possible. Those using the contract approach need to realize the advantages and the disadvantages of this type of program. It requires (1) a variety of reference materials, (2) a variety of audio-visual materials for student use, (3) laboratory equipment and (4) an environment for individualized study. In addition the implementation of such a program presupposes student development in basic study skills such as reading, interpreting, analyzing, projecting and recording, a level of individual competency in responsibility to perform the activities and an attitude for learning. However, the contract method gives the student the opportunity to explore in great depth and avoids the lock step of a highly structured curriculum or the hindrance of a teacher dominated class situation.

The following unit was redesigned from materials developed for grades 4-5-6 by the Upper Red River Valley Educational Service Center at Grand Forks.

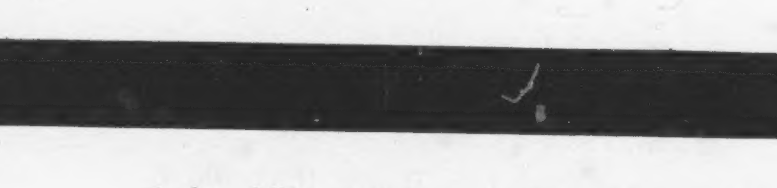
ENERGY AND MOTION

I. Content Classification
Friction

II. Objectives

The student should be able to:

- —identify at least two factors that influence the amount of friction between surfaces
- —identify at least three examples in which friction is a help



- —identify at least three examples in which friction is a hindrance
- —identify at least five ways of reducing friction
- —identify at least five ways to increase friction
- —demonstrate that friction produces heat

—construct a definition of friction

—demonstrate that friction makes it difficult to slide one object against another

—demonstrate that friction is reduced by bearings and lubrication

—demonstrate that friction is useful in stopping moving objects

III. Sample Test

A. Multiple choice.

—1. Whenever two things rub against each other there is
(a) lubrication, (b) friction

B. List three ways in which friction is a hindrance.

C. Accuracy: 20 out of 25 correct

IV. References

A. *The Expanding World of Science*, Bobbs-Merrill, 1969, Bk. 4, pp. 243-248

B. *Science in Your Life*, Heath, 1968, Bk. 4, pp. 222-234; 238

C. *Now Try This; Lab Man*, Heath, 1966, Bk. 4, pp. 70-76

D. *Searching In Science*, American Book Co., 1968, pp. 110-117

E. *Probing Into Science*, Am. Bk. Co., 1968, Bk. 4, pp. 151; 280

F. *Science Through Discovery*, Singer, 1968, Bk. 4, pp. 99-105

G. *Science 5*, Laidlaw, 1966, pp. 161-162

H. *Science 5*, Silver Burdett, 1968, pp. 166; 193-196

I. *Science for Tomorrow's World*, Macmillan, 1966, Bk. 4, pp. 44-52

J. *Science a Modern Approach*, Holt, Rinehart, Winston, 1966, Bk. 3, pp. 127-131

K. *Elementary Science Handbook*, 1961, pp. 119-120

L. Filmstrip: *Friction at Work*, Young America Films; *Reducing Friction on Land*, Young America Films

V. Instructional Procedure

A. Teacher-led motivating presentation

B. Do worksheet I using the above references

C. Perform at least two of the experiments under Activities A-D. Write your observations in your notebook

D. Do worksheet II

E. Perform at least 3 of the experiments on reducing friction. Activities E-I.

F. Do Activity J or L

G. With a group do Activity K

H. Take the evaluation

VI. Activities

A. Experiments to produce friction
See the reference J, p. 127; K, p. 119 No. 1331 or C, p. 73

B. To see the use of friction
Reference B, pp. 232-233 or C, p. 69, 74

C. Experiment to see the results of friction
Reference F, p. 100

D. Measure friction
See reference K, p. 119 No. 1328 & 1329 or J, pp. 128-129

E. Experiments: To compare materials used in reducing friction
See reference J, p. 130; H, p. 199 No. 3; B, p. 224-231 or C, p. 71

F. Experiment to reduce friction with lubricants
Ref. K, p. 120 No. 1334-1336; B, p. 229

G. Experiment: Reduce friction with ball bearings
Ref. B, p. 230; C, p. 72; J, p. 130 or K, p. 120 No. 1337 or 1339

H. Experiment: To reduce friction with wheels
Ref. B, p. 228

I. Experiment: Reduce friction with rollers
Ref. B, p. 226 or 231; F, p. 101

J. Write a short story on what would happen if all friction suddenly disappeared.

K. Make a display of toys and models showing ways of moving things on land.

L. Tell what would happen in a baseball game if there were no such thing as friction. How do spikes, friction tape and resin bags help?

Worksheet No. 1

A. Write true for the correct statements.

If false, correct the underlined word.

1. When two surfaces rub against each other there is friction.

2. Rolling friction is greater than sliding friction.
3. There is less friction between rough surfaces than between smooth ones.
4. More force is needed to move a load when there is more friction to overcome.
5. Catching and dragging on rough surfaces eliminates friction.
6. Friction produces heat.
7. Friction between the boat and the water is called fluid friction.
8. Casters and wheels are used to increase friction.
9. Oil and grease are used to reduce friction.
10. Friction is used to stop bicycles and cars.
11. Resistance comes from a word meaning "to make slippery."

B. Many accidents in the home are caused by sliding or slipping. These can be prevented if you think about the way friction keeps things from sliding.

How could you use friction to keep these accidents from happening?

1. Slipping in the showers or bathtub
2. Falling on slippery floors
3. Falling when rugs slip
4. Slipping on icy sidewalk or steps

C.

1. When the hands are rubbed together real fast ———— is noticed.

2-6. List five examples where friction produces heat.

7-10. List four examples in which friction is a hindrance.

11-13. Three factors that determine the amount of friction between two surfaces.

14-18. List five ways to increase friction.

Worksheet No. 2

A. Write each pair of words in the column in which it fits.

	More friction	Less friction
ex.:	Sliding	Rolling

1. Sand - ice
2. bare hands - wool gloves
3. loose shoe - shoe that fits
4. glass - rough boards
5. new tires - old tires
6. railroad tracks - road
7. wet street - dry street
8. sneakers - leather shoes
9. sharp ice skates - dull ice skates
10. rusty roller skates - oiled roller skates

B. List 5 devices man uses to increase friction:

————, ————, ————, ————, ————

C. Name at least 5 ways man has found to make work easier by reducing friction.

D. Can you tell which of these would stop more quickly? Why?

1. a sled with steel runners on ice.
2. a sled with wooden runners on ice.
3. a sled with steel runners on fresh snow.

EVALUATION

A. Choose the right word or words. Place the letter on the line provided.

—1. There is (a) more (b) less resistance on a rough road than on a smooth road.

—2. Catching and dragging on rough surfaces causes greater (a) weight (b) friction (c) force.

—3. Much force (a) is (b) is not, needed where there is less friction.

—4. A heavy object offers (a) more, (b) less, resistance than a light one.

—5. Reducing friction with a liquid is called (a) inertia (b) resistance (c) lubrication.

—6. Some friction when you are walking is an (a) advantage, (b) disadvantage.

—7. There is more friction on (a) wet street (b) paved street (c) gravel street.

—8. Friction is a (a) hindrance (b) help, to start a load moving and to stop it.

—9. (a) Ballbearings (b) Wheels (c) Rollers, contain rolling steel balls which reduce friction.

—10. When two surfaces rub against each other there is (a) thrust (b) inertia (c) friction.

B. List the following

1-4. Uses of friction
5-8. Ways of reducing friction
9-10. Ways in which friction is a hindrance
11-12. Two factors that determine the amount of friction between two surfaces
13-15. Ways to increase friction

Worksheet Keys

Worksheet No. 1

A.
1. true
2. false, less
3. false, more
4. true
5. false, increase
6. true
7. true
8. false, decrease
9. true
10. true
11. false, lubricant

B.
1. Rubber mat
2. Walk slowly, carefully
3. Use friction pad under rug
4. Add sand or salt

C.

Any answer acceptable that the student can show reasoning

Worksheet No. 2

A.
1. sand
2. wool gloves
3. plowed ground
4. rough board
5. new tires
6. road
7. dry street
8. sneakers
9. dull ice skates
10. rusty roller skates

B. Any five are acceptable

C. Any five are acceptable

D. Fresh deep snow would stop the sled quickly

Evaluation Key

A.
1. a
2. b
3. b
4. a
5. c
6. a
7. b
8. b
9. a
10. c

B.

1-4. brakes, tread on tires, tape on bat, graphite in pencil, traction mats, grip in walking, etc., keeping a nail or screw in board, keeping lid on a jar.

5-8. use of lubricants, oil, grease, wax, graphite, ball bearings, polish, rollers, wheels, foam.

9-10. makes a machine or object hard to push, causes heat in a motor, or moving parts, makes work harder, etc.

11-12. kind of material, weight, type of surface

13-15. increase weight, add sand to ice, make surface rough, studs on snow tires, use tennis shoes in gym, etc.

Unit—Air (Environmental Education)

Man's existence is totally dependent on an ecologically sound environment. Ironically, man is destroying his environment. Thus, man is in danger of destroying himself.

Man's ignorance, greed, indifference, and expediency result in environmental destruction and resource exploitation. Present efforts to reverse these trends are outstripped by our lack of concern for ultimate consequences. World population continues to grow while per capita share of the world resources continues to shrink. Natural resources—soil, water, atmosphere, forests, wildlife, natural beauty, minerals—are still deteriorating because of many continued practices which violate ecological principles. Truly, man has already destroyed much of what makes life worth living and is on the verge of destroying the ecological web that supports human existence.

The only hope for stemming this destruction is through environmental education both in and out of school. Children need to be taught the principles of ecology, conservation and environmental preservation. Such education must be based on ecological principles; instill awareness, appreciation, conservation and responsibility of and for the environment; and demonstrate that man affects every facet of the environment and the environment affects every facet of man's life.

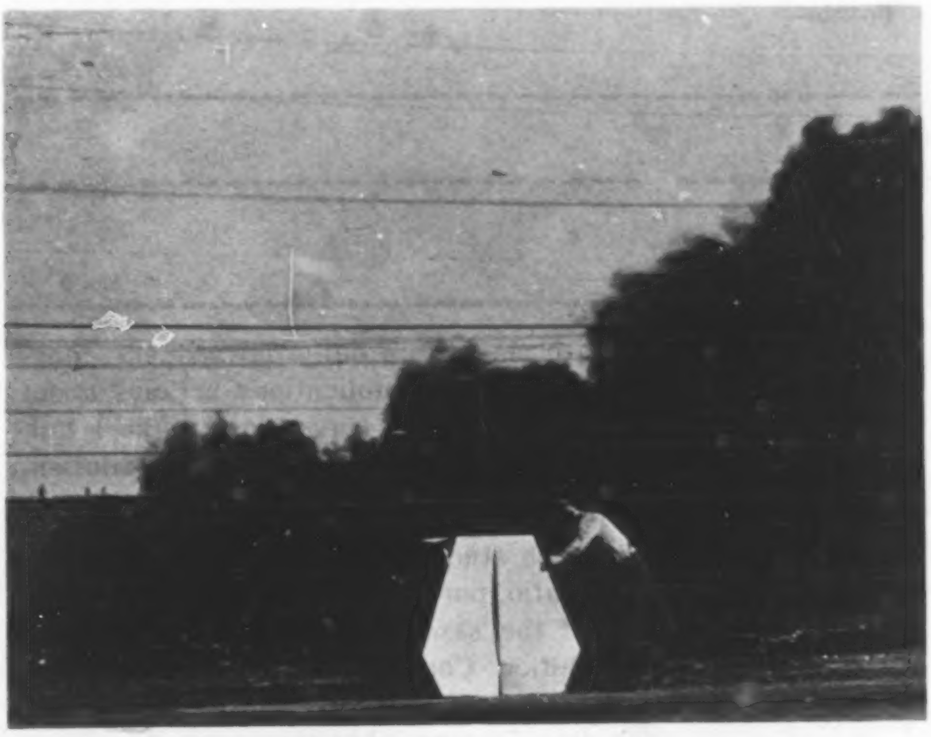
There is an envelope of air some 250 miles thick surrounding the earth. Ninety per cent of the atmosphere is within 19 miles of sea level and man can live and work productively only within the first two miles above sea level. The air supports animal, plant and human life plus numerous other uses. One person inhales about 6,000 gallons of air daily and if one lives in an industrial area he would inhale millions of particles of foreign matter with the air. Air pollution is preventable, but it requires the efforts of all mankind.

Environmental education, ecology, or conservation can be taught as an integrated part of any and all subjects. Conservation is a part of everything we teach. It is so intimately associated with every phase of our daily lives that it cannot be held apart.

The following is a unit for the intermediate grades on "air."

Basic Concepts	*Pupil Activities*
A. Clean, breathable air is needed for the support of all life.	List the principle sources of smoke and other forms of air pollution in your community. On the map, draw an arrow showing direction of the prevailing winds. Tell how air pollution is affected by natural forces such as wind, snow, rain.
B. Air pollution covers the entire spectrum of contaminants—smoke, dust, blowing soil, fumes, mists, radioactive wastes, odors, gases, pesticides, and a combination of these.	
C. Air pollution is as old as "time."	
D. Air pollution increases as the population increases.	
E. Man's personal activities dirty the air: automobiles, jet planes, home heating, and refuse disposal.	Bring to class from daily newspapers, magazines and other publications articles about pollution of the air. Have class make a bulletin board of these articles on air pollution.
F. Industrial activities dirty the air: manufacturing processes, power generation, and refuse disposal.	Have each student place a large white cloth on his patio, porch or lawn. Keep one control cloth of the same material away from the air pollution. Compare the fall-out and color on the exposed cloth with the clean cloth each day. Discuss what this extra dirt from the air can mean to the cost of running a city, a home and a business.
G. Man's health is the most important factor in the consideration of dirty air.	How does dirty air affect man's health?

H. Air pollution is a social problem.	Invite a local industry leader, or a state air conservation official to speak to the class. What civic actions are necessary to reduce air pollution?
I. Hills and valleys may trap stagnant air and cause pools of pollution.	
J. Most gases and dusts can be collected with mechanical equipment before they are released into the air.	Find out what methods some industries have used to prevent air pollution.
K. Air pollution is an economic problem.	Locate on a map the areas where industrial and agricultural air pollution is most concentrated; where population centers are found, note similarities between air pollution, industrial expansion, and population growth.
L. Air conservation is a personal responsibility.	Write a short paragraph about how you can help to prevent air pollution.



Part Three

Instructional Aids

In-Service Training for Science Teachers

IN-SERVICE TRAINING can make a valuable contribution to the development and implementation of a science program. The in-service suggestions listed below are several ways local school districts might explore ways to improve their science programs.

1. Schools should contact the science consultant in the Department of Public Instruction as to the possibilities for an in-service training program.
2. Use a well-trained science teacher to conduct workshops — demonstrating to other teachers techniques and methods of presentation of science concepts.
3. Use other resource persons to conduct workshops.
4. Teachers could attend evening or Saturday classes at nearby institutions of higher learning.
5. Encourage teachers attending summer school to take science courses.
6. Conduct "Do-it-yourself" meetings for preparing instructional materials.
7. Release time for observation of more experienced teacher with follow-up conferences for growth of both teachers.
8. Have a standing science committee for continued growth and evaluation.
9. Provide help for new teachers through lesson planning, special science techniques and selection of materials for children's and teacher's needs.
10. Increase professional and reference libraries.
11. Stimulate interest in exhibits, demonstrations, and fairs.

The quality of science instruction at any level is determined largely by the capability of the classroom teacher. In-service training has been one approach to the problem of increasing teaching competence. For greater effectiveness, what criteria should be set up to guide the design of an in-service training course in science for elementary school teachers?

Here are a number of questions that may be useful in focusing attention on some guiding principles.

1. Is the training course based upon a planned science curriculum?
2. Is the course set up to give teachers confidence in their ability to teach science?
3. Does the course help the teachers become aware of the spirit of science and the purposes of science instruction?
4. Does the course pave the way to understanding of basic science principles?
5. Does the course show teachers how to activate children and get them to think?
6. Does the course help the teachers become familiar with science teaching materials and aids?
7. Does the course provide a background of information and knowledge without overwhelming and frustrating the teachers?
8. Does the course provide guidance in the allotment of time for science teaching?
9. Does the course feature a program of first-hand experiences and experiments for children?
10. Is the course based on lectures or workshop activities? In other words, are the teachers taught in the same ways that they are expected to teach?

Elementary Science Source Book

In 1963 the Department of Public Instruction published the first two volumes of *An Elementary Science Source Book*, Volume Three in 1967, and Volume Four in 1968. The books are reprints of "The Cornell Science Leaflets." The material is excellent as a reference for teachers and in some cases for students. The topics are of great variety and will provide information not easily found. Most of the material is written by Dr. Verne N. Rockcastle, College of Agriculture, Cornell University, Ithaca, New York.

The first two volumes contain leaflets written between 1958-1962. Volume Three contains the leaflets from December 1962 through May 1965. Volume Four contains the leaflets from September 1965 through May of 1968.

Volume One contains material that is more related to life science such as the articles, "Keeping Animals in the Classroom;" "Food Chains"; "Amphibians"; "Reptiles"; "Birds"; "Ancient Sea Life"; "Plants Without Flowers"; "Seeds"; and "Little Climates."

Volume Two is more related to the physical science such as "Weather"; "Earth and Beyond"; "Let's Measure"; "Simple Machines"; "Light"; "Making Black and White Photographs"; "Sound"; "Chemicals in Action"; "Electricity and Magnetism"; "Science Experiments in the Classroom."

Volume Three contains a variety of articles such as "Science Equipment"; "Conservation"; "Fungi"; "Atoms"; " 'Round and 'Round"; "Nature Poetry"; "Liverworts and Mosses"; "Microbes"; "Winter Twigs"; "Invitation to Experiment"; "Ferns and Their Allies."

Volume Four contains the most recent articles in the Cornell Science Leaflet series with such topics as "Science Books for the Elementary School"; "Animal Traces"; "Keeping Time"; "Decay"; "Pond Life"; "Spiders"; "Balancing Act"; "Electric Circuits and Charges"; "Water Wonders"; "Snow and Ice"; "Bits Made Big"; and "To and Fro."

National Elementary Science Curriculum Projects

There are many curriculum studies in progress on a national level. These programs should be watched and the ideas developed may help your local program and in some cases the total curriculum could be adopted. The four projects listed below are receiving much attention. The March 1968 issue of "Science and Children" has a more complete list.

Elementary Science Study (ESS), 55 Chapel Street, Newton, Massachusetts 02160. *Purpose*: To develop meaningful science material for use by children centered around open-ended investigations. Materials are designed to resemble items common to children's environment. (K-8) *Presently Accomplished*: Over thirty science units consisting of text material, equipment, activity suggestions, teacher's guides, and films. *Project Evaluation*: The study method of making evaluations. Design of evaluative instruments underway that will reflect non-verbal emphasis of the units. *Future Plans*: Production of additional commercial units. Further methods will be explored to help schools and teachers make effective use of the materials and to find ways to extend impact of science units to other curriculum areas. *Materials for Purchase*: A number of units, kits, teacher's guides, films, filmloops are available from Webster Division, McCraw-Hill Book Co., Manchester Road, Manchester, Missouri. *Free Materials*: Brochure and reprints of magazine articles describing project, price list, and ESS Newsletter.

Minnesota Mathematics and Science Teaching Project (Minnemast), 720 Washington Avenue, S.E., Minneapolis, Minnesota 55414. *Purpose*: To produce coordinated mathematics and science curriculum for grades K-6, and organized materials for inservice education of teachers. *Presently Accomplished*: Minnemath Reports, Mathematics and Science units. *Project Evaluation*: Classroom materials are being used on experimental basis in classrooms under supervision of cooperating colleges. Student reactions and achievement tests. *Future Plans*: Curriculum materials for coordinated science-mathematics, through grade 6. *Materials for Purchase*: Curriculum Units available at cost. Prices on request. *Free Materials*: Minnemath Reports.

Science — A Process Approach (AAAS), American Association for the Advancement of Science, 1515 Massachusetts Avenue, N. W., Washington, D.C. 20005. *Purpose*: To develop an elementary science program which emphasizes the laboratory method of instruction and focuses upon ways of developing basic skills in the processes of observing, classifying, measuring, predicting, and other skills needed for science investigation. *Presently Accomplished*: Science — A Process Approach in seven volumes, Commentary for Teachers, Guide for Inservice Instruction, monographs explaining the program, articles in science journals, films, equipment kits for parts one through seven. *Project Evaluation*: Competency measures for each exercise; process instrument-annual progress assessment; control groups, feedback process, research evidence of objectives achieved. *Future Plans*: Commercial editions and revised kits of equipment and supplies are being developed. Revisions and extensions of evaluations, inservice training programs, production of additional films. *Materials for Purchase*: Commercial editions and equipment kits for all parts from the Xerox Corp. Teachers commentary and Guide available from AAAS. *Free Materials*: Newsletter, a monograph describing the program, "The Psychological Bases of Science — A Process Approach." Reprints of Articles. Price list.

Science Curriculum Improvement Study (SCIS), Lawrence Hall of Science, University of California, Berkeley, California 94720. *Purpose*: To develop in children an investigative attitude and a functional understanding of fundamental concepts in both the physical and biological sciences. (K-6). *Presently Accomplished*: Science units involving work on 1. material objects, 2. organisms, 3. interaction, 4. life cycles, 5. subsystems, 6. relativity, 7. temperature, and 8. position and motion. *Project Evaluation*: Teacher reaction, classroom testing of students in program. Behavioral outcomes identified. Teachers given in-service training to assess student progress. *Future Plans*: The preliminary edition of units will become available at the rate of three units per year. Work will continue on additional units and on teacher training and feed back programs. *Materials for Purchase*: Teacher's guides for Units and Background of SCIS. Class room kits. *Free Materials*: Newsletter, "So Little Done, So Much to Do" by C. A. Lawson, "Toward Scientific Literacy" by Karplus and Thier. Article reprints.

The new programs all seem to lend themselves to the following ideas:

1. From an emphasis on accumulating knowledge . . . to an emphasis on how to find and create knowledge.
2. From questions of what is the name of,

the color of, the weight of, the length of . . . to questions of *how* and *why*.

3. From science as a noun . . . to "sciencing" as a verb.

4. From a parade of the dead, preserved embalmed, pickled, pressed, imbedded, immobile, and often distorted specimens . . . to frogs that jump, fish that swim, rabbits that hop, birds that fly, flowers that smell, and worms that wiggle.

5. From a lab manual with the right blanks, right spaces, right lines for the right answers . . . to a lab manual with blank pages headed with questions.

6. From a sketchy instruction in all the ideas of science . . . to a systematic preselection of content.

7. From a study of separate science disciplines, almost compartments of isolated knowledge . . . to a broad, flexible program based on the unity of science.

8. From much use of one textbook, maybe even one in a series . . . to use of multiple texts and many books.

9. From a "pouring it on" in larger doses of more facts faster . . . to exploration in depth.

10. From science as something to be learned from books and from listening . . . to something that grows out of direct experiences.

11. From demonstrations only by the teacher . . . to open-ended laboratory experiences for the student with research opportunities.

12. From memorization to discovery.

Safety in Science Teaching

Because good science instruction involves the use of a wide variety of equipment and materials, the risk of accidents and injury is always present. It is urged that all teachers be aware of precautions which can be taken to reduce this risk.

All children must develop sensible attitudes in relation to taking safety precautions in working in science. Attitudes determine behavior and cannot be taught as abstractions. Children's safety attitudes are built from experiences they have. The school has a responsibility to teach safety. Safety attitudes and behaviors should be taught through situations that fall within the range of a child's own experience. Simple explanations of what not to do must be reinforced with reasons that children can understand. Science requires active participation, and thus the teaching of safety practices is essential. The best guide to safety in science is the use of good common sense by children and teachers.

GENERAL SAFETY PRACTICES

1. A teacher should work through the handling of equipment and materials, find out about all possible hazards, and be sure that the experience is a reasonably safe one before proceeding.

2. Teachers should practice general safety procedures in relation to the use of fire and instruct children in how to take appropriate precautions. Teachers should consult with the principal regarding fire regulations.

3. At the beginning of any experience, if there is any special hazard, children should be specifically instructed regarding the recognition of dangers and the precautions to be taken. This particularly includes experimentation and field trips.

4. If children are working in groups with limited amounts of equipment, each group should be small enough to prevent confusion which might result in accidents.

5. When using equipment that might present special hazards, individual and group work should be arranged in the classroom so there can be constant teacher supervision.

6. All accidents resulting from the handling of equipment should be reported to the teacher.

7. Children should never carry equipment through the halls when classes are passing.
8. Children should be allowed sufficient time to perform experiments, because haste sometimes causes accidents.
9. Any piece of equipment that has been heated (microprojector, hot plates, A.V. devices) should not be moved until it has cooled.
10. Hazardous materials and equipment should be kept in a safe place.
11. Before permitting children to work with sharp tools, the teacher should be assured that children are competent to use these tools and are closely supervised while the tools are being used.
12. It is to be remembered that there is always danger when heating a liquid.
13. Glass wool and steel wool should be handled with gloves.

SAFETY IN RELATION TO ANIMALS AND PLANTS

1. All mammals used in a classroom should be inoculated for rabies, unless purchased from a reliable scientific company.
2. The following animals should never be brought into the classroom: wild rabbits, snapping turtles, poisonous snakes, or insects that may be disease carriers. Children should not bring their pets to the classroom unless the activity is carefully planned by the teacher.
3. Before a small animal is brought into the classroom for observation, plans should be made for proper habitat and food. The living quarters of animals in the classroom must be kept clean, free from contamination, and secure enough to confine the animals. Plans should be made for care of the animals over the weekends and during vacation periods.
4. Animals should be handled only if it is necessary. This handling should be done properly according to the particular animal. Special handling is required if the animal is excited, is feeding, is pregnant, or is with its young.
5. Children should wash their hands after handling turtles, snakes, fish, frogs, toads, etc. Also, the water from the habitat should be disposed of carefully.
6. Children should be cautioned never to tease the animals or to insert their fingers or objects through wire mesh cages.
7. Any child who is bitten or scratched by an animal should report it immediately to the school nurse.
8. After a period of animal observation is completed, animals should be returned to their natural environment.
9. Before taking study trips into wooded areas, identify and discuss plants which produce poisonous effects.
10. The use of flowers and mold which have excessive spores should be used with caution because of possible allergies of children.
11. There is a great danger of contamination from bacteria cultures unless sterile techniques are used.

SAFETY WITH CHEMICALS

1. Label all bottles so that their contents may be identified.
2. Pupils should never test unknown chemicals by taste or touch.
3. Chemicals should never be mixed just to see what will happen.
4. If volatile or flammable liquids are used in a demonstration, extreme care should be taken to insure that hot plates or open flames are at safe distances from the fumes.
5. Rosin, shellac, alcohols, charcoal, etc., should be stored in glass-stoppered bottles or in bottles with plastic tops.
6. Combustible materials should be kept in a metal cabinet equipped with a lock.
7. Chemicals should be stored in a cool place.
8. Children should never experiment with rocket fuel propulsion devices.
9. Volatile substances which are spilled should be disposed of in fire-proof receptacles.

10. The use of such preservatives as formaldehyde and alcohol demands protection for the skin. Preserved specimens should be washed in clean water and kept in salt water for use during the day. To remove specimens from preservatives, use tongs and rubber gloves.

SAFETY WITH ELECTRICITY

1. At the beginning of the study of a unit on electricity, children should be told not to experiment with the electric current of home and school circuits.
2. Children need to be taught safety precautions regarding the use of electricity in everyday situations.
3. Children should never handle electric devices immediately after their use because these devices might retain a high temperature for a period of time.
4. To remove an electric plug from a socket, pull the plug and not the cord.
5. It is to be recognized that short-circuited dry cells can produce a high temperature which can cause a serious burn.
6. Storage batteries are dangerous because of the acids that they contain and the possibility of short circuits within them.

SAFETY WITH GLASSWARE

1. Glassware which is to be heated should be only Pyrex or a similarly heat-treated glassware.
2. All glass tubing used with corks or stoppers should be fine polished or have the edges beveled with emery paper.
3. A soap solution or glycerine should be used on the top of glass rods or tubing for lubrication before inserting them into a cork or stopper. Tubing should be wrapped with several layers of cloth or in a rubber tubing holder. The tubing should be held as close to the cork as possible.
4. Corks should be removed from tubing to keep them from adhering and "freezing." "Frozen" stoppers can be removed by splitting them with a razor blade and then reclosing them with rubber glue.
5. Broken glassware should be disposed of in a special container marked "BROKEN GLASS."
6. The fingers should never be used to pick up broken glass. A whisk broom and dustpan can be used for large pieces, and large pieces of wet cotton can be used for very small pieces.
7. Glassware should be thoroughly cleaned after use.
8. Children should never drink from glassware that has been used for science experimentation.
9. Sharp edges on mirrors or glassware should be reported to the teacher.
10. Glass objects which might break should be wrapped with plastic wrap or wire screening.

NOTE

Elementary teachers can receive many helps in handling equipment by referring to the ninth grade physical science manual published by the Department of Public Instruction found in all North Dakota High Schools. The first unit in the manual called "Laboratory Procedures," pp. 1-36, is excellent.

Physical Facilities (grades 1-6)

It has been said on numerous occasions that a competent teacher can do a satisfactory job of teaching in a bare room. While this may be true, adequate facilities and supervisory services will enhance his productivity. Teachers should have the best facilities possible to help them make their science teaching more effective.

While the specific requirements for physical facilities will vary from level to level, it must be recognized that learning activities must be aimed toward the problems significant to the learner.

In general it is desirable to have a special room to teach science where there are moveable tables, storage, utilities, display area, plant and animal areas, and long-term project areas available. Self-contained classrooms serve most adequately when they have sinks, water, electrical outlets, facilities for using audio-visual aids, bulletin boards, storage space, and work area. These facilities have been built into most of the newer schools with sink and counter space in the back of the room. In some cases, storage is not adequate. Students can arrange their desks in groups and do most of the science activities.

Individual participation at all levels is basic for the development of science concepts. If children are to make discoveries and solve significant problems, certain kinds of equipment or materials need to be sufficiently available so that children can work individually or in small groups.

Storing Materials: Some elementary schools have science rooms especially equipped for science instruction and storage of equipment. If these are not available, a central science depot and storage room might be established. The room should be readily accessible to all teachers and should be under the supervision of a teacher familiar with the equipment. To facilitate checkout and use by teachers, the materials should be arranged and stored according to a topic plan. For example, small items can be stored in appropriately labeled plastic tote trays or discarded shoe and cigar boxes. Some of the trays might be labeled "electricity," "magnetism," "rocks and minerals," and so forth. This system facilitates the moving of science materials from room to room by the teachers or children using carts.

Science Equipment and Material

A modern elementary school science program should be one that includes student and teacher experimentation and investigation. A program of this type cannot be accomplished without a supply of equipment and materials sufficient to allow the involvement of all the children. The materials and equipment used at the elementary science level should be simple, easy to handle, and readily available. The supplies fall into these general categories: (1) those which can be brought in by the children from their homes or easily obtained by the teacher from the community; (2) those which can be obtained from the science teachers in the secondary schools of the system; (3) those

WHERE DOES EVERYONE GO?

which must be purchased from scientific supply companies; and (4) those which may be made by the teacher and/or students.

Science equipment and materials can be divided into two groups: (1) basic materials in the classroom which are available to the teacher and pupil at all times, and (2) more expensive science equipment kept in a central storage area and available to all teachers whenever needed. The materials which belong to the first category include hand tools, (pliers, screwdriver, hammer, saw) dry cells, an assortment of wire, small electric lamps and sockets, bottles, jars, etc. The more expensive materials include microscopes, a microprojector, barometers, electrical measuring instruments (meters), lenses, demonstration models, etc.

OBTAINING SUPPLIES: It is frequently advisable to obtain the aid of science teachers when ordering supplies and equipment from scientific supply companies. Before ordering the supplies, carefully study the catalogs of the various companies and check the materials against those suggested by the curriculum guide you are using in teaching science. When ordering, be certain to indicate the catalog number, size, quantity, and quality. Make certain that you order exactly what you require to avoid the inconvenience of exchanging items after delivery. The Department of Public Instruction does not stock or furnish science equipment or supplies. These may be obtained from commercial houses.

The following is a suggested list of materials to teach elementary science. How much of each item will be necessary depends upon how large the school is, how much individual experimenting is to be done, and whether or not this equipment is to be routed from one school to another. Some school systems prepare kits of material useful for teaching specific units (electricity, sound, etc.) which are available upon request from a central place and are returned after use. Many items may be purchased locally.

Living Things

Animal cage
Ant box
Aquarium
Binoculars
Cover glass
Dissecting set
Growing plants
Incubator
Insect collection
Insect killing jar
Insect net
Leaf collection
Magnifying glass
Micro-projector
Microscopes
Models of body parts
Plant press
Pots for plants
Seed collection
Stereo microscope
Stethoscope
Slides, blank
Slides, prepared
Spreading board
Terrarium

Beyond the Earth

Celestial globe
Globe, physical
Sun dial
Telescope

Planetarium
Star guide
Theodolite

Earth

Aneroid barometer
Anemometer
Cloud chart
Compass
Inside thermometer (Fahrenheit)
Mineral collection
Outside thermometer (Fahrenheit)
Rain gauge
Rock collection
Soil samples
Dew point apparatus
Fossils collection
Hardness kit
Hygrometer
Streakplates
Weather map
Weather vane

Matter and Energy

Ammeter
Bar magnets
Compass (magnetic)
Electric lamps, small
Electric motor
Electric sockets, small
Electromagnet
Electroscope
Glass friction rod
Iron filings
Telegraph key and sounder
Copper wire
Dry cells
Electric bell
Lodestone
Push button
Rubber friction rod
Switches
U. magnet
Voltmeter

Sound

Slinky toy
Tuning forks
Whistle, slide
Xylophone (toy)

Light

Cellophane (colored)
Color top
Concave - convex mirror
Convex lens
Flashlight
Paper (colored)
Prism
Radiometer
Reading glass
Small plane mirrors

Heat

Ball and ring
Compound bar
Thermometer (Celsius & Fahrenheit)
Thermometer demonstration
Hot plate

Machines and Measuring

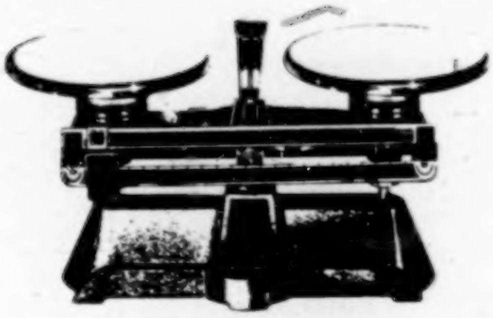
Balances and weights
Graduated cylinder
Inclined plane
Inclined plane car
Meter sticks
Pulleys
Ruler (inches and cm)
Scales (spring)

Miscellaneous

Bags, paper
Baking soda
Balls
Beakers
Boxes
Candles
Corks
Dyes
Evaporating dish
Jars
Knife
Litmus paper
Marble chips
Marbles
Medicine dropper
Nails
Overhead projector
Pins
Plaster of Paris
Pliers
Red ink
Ring stand
Rubber bands
Rubber tubing
Salt
Sandpaper
Saw
Viewer for slides and filmstrips
File
Film projector 16 mm
Filmstrip projector
Flasks
Funnels
Forceps
Glass tubing
Gloves
Hammer
Screwdriver
Slide projector
Sponges
Starch
Steel wool
Straws (soda)
String
Stoppers, rubber
Sugar
Super 8 mm projector
Tacks
Tape
Tape recorder
Test tube brush
Test tube holder
Test tubes
Tongs
Vinegar

ILLUSTRATIONS OF COMMONLY USED SCIENCE EQUIPMENT

The following diagrams are provided in order to assist in the identification of pieces of equipment which are frequently referred to and used in a science instructional program.


Balance

Balance, Spring

Ball and Ring

Expansion Bar (Bimetallic)

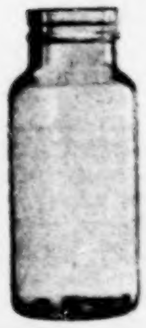
Aneroid Barometer

Battery, 1½ Volt

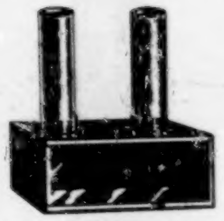
Beaker

Bell, Electric

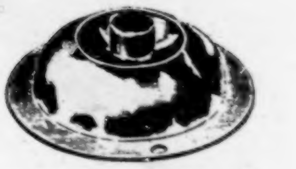
Blowpipe



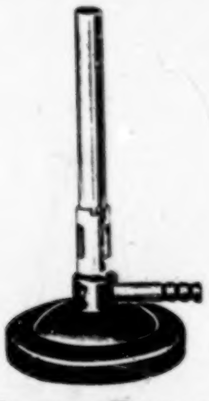
Wide-Mouth Bottle



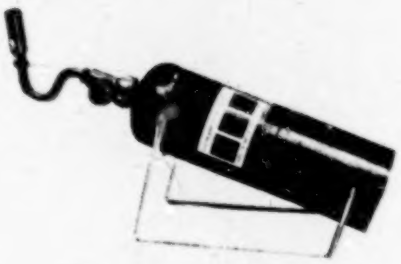
Convection Box



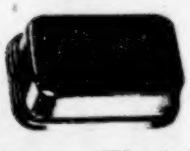
Push Button



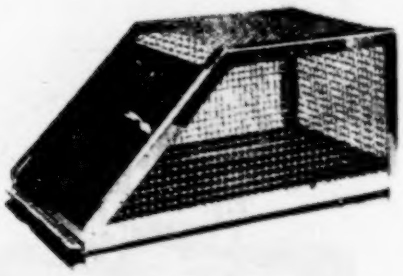
Burner, Bunsen



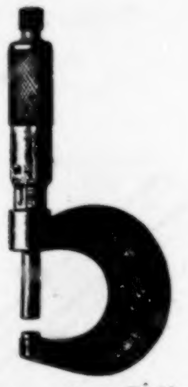
Burner, Propane Gas



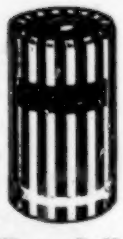
Buzzer, Electric



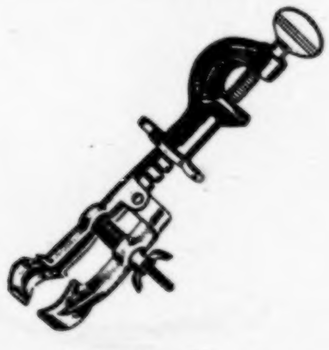
Animal Cage



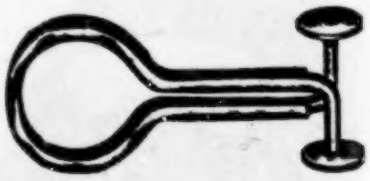
Micrometer Caliper



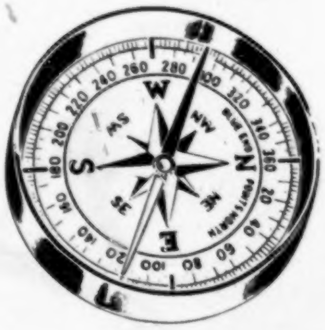
Dry Cell



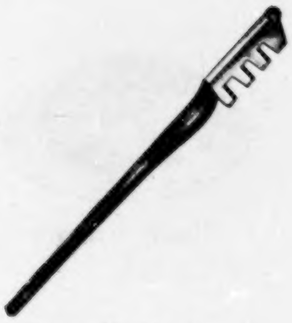
Burette Clamp



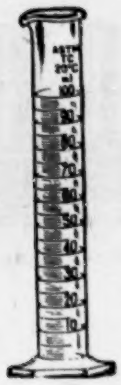
Tubing Clamp



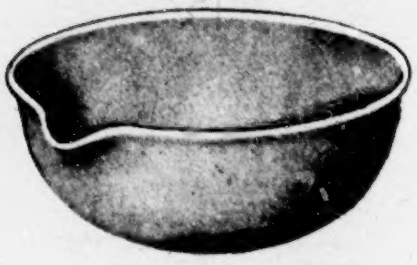
Compass



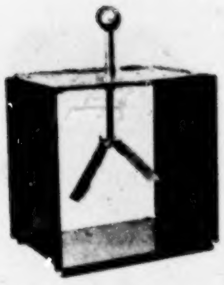
Glass Cutter



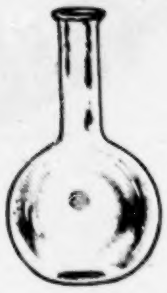
Graduated Cylinder



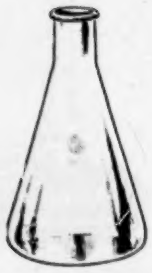
Evaporating Dish



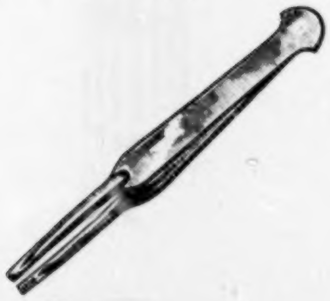
Electroscope



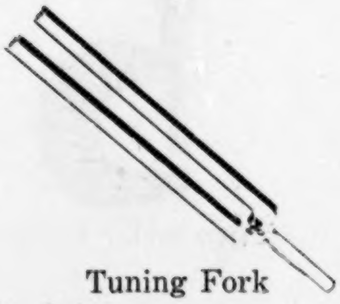
Boiling Flask



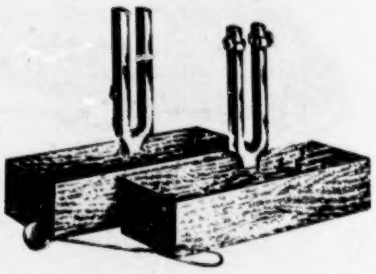
Erlenmeyer Flask



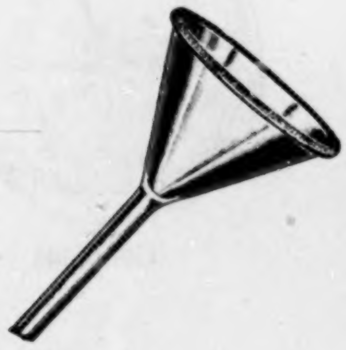
Forceps



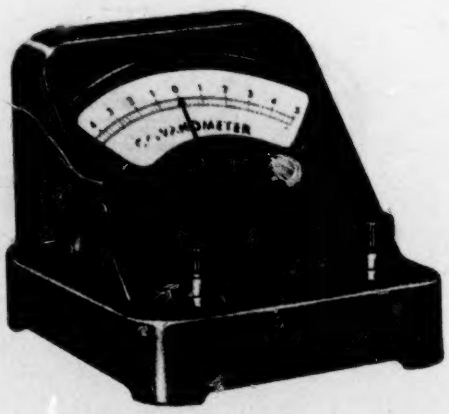
Tuning Fork



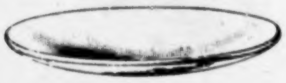
Sympathetic Tuning Forks



Funnel

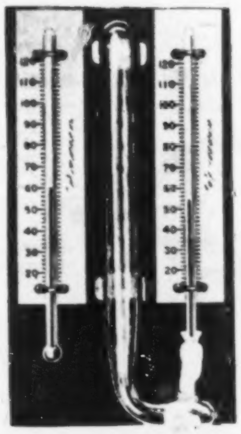


Galvanometer



Watch Glass

Gyroscope



Hygrometer, Wet-and-Dry-Bulb

Battery Jar

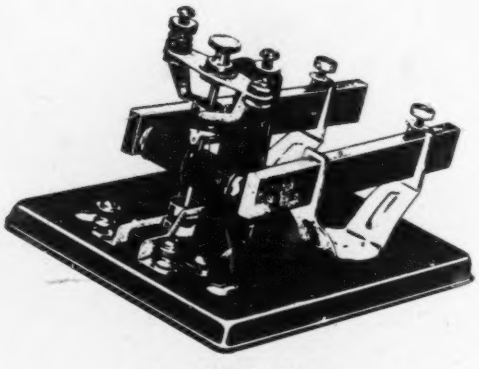
Bell Jar

Alcohol Lamp

Magnifier

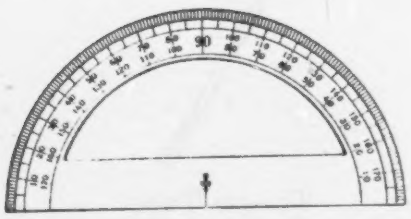
Microscope

Mortar and Pestle



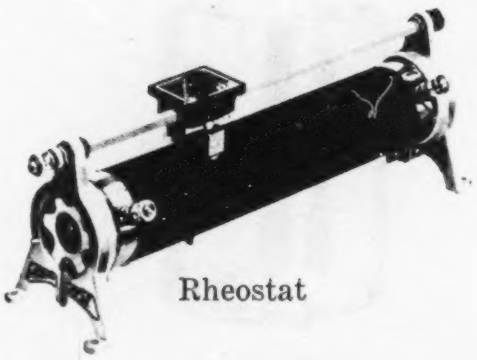
St. Louis Motor

Ant Nest

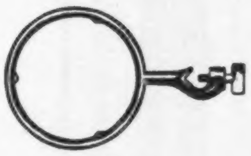


Protractor

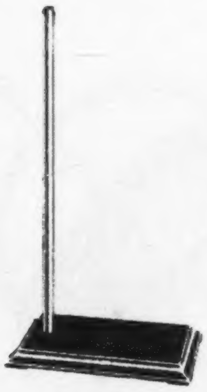
Pulley



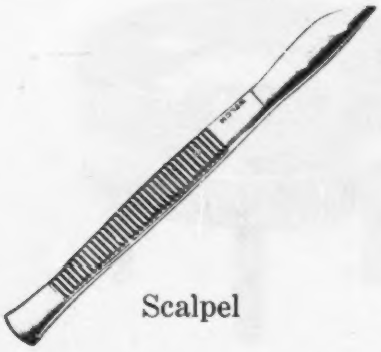
Rheostat



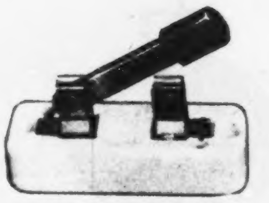
Ring



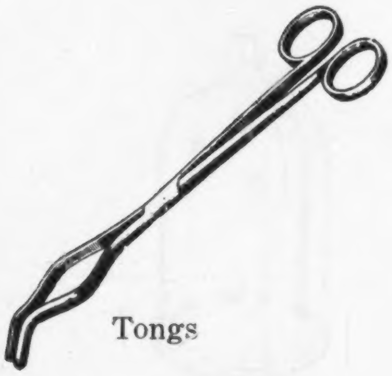
Ring Stand



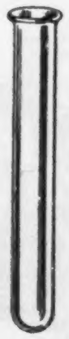
Scalpel



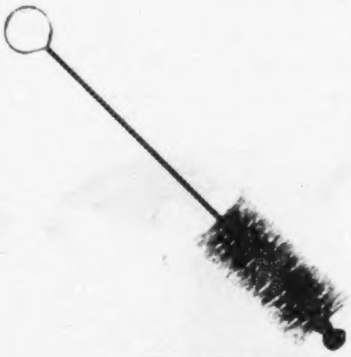
Switch, Knife



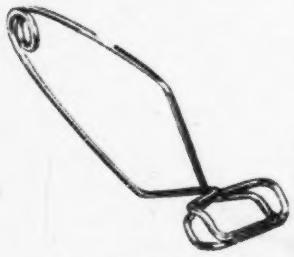
Tongs



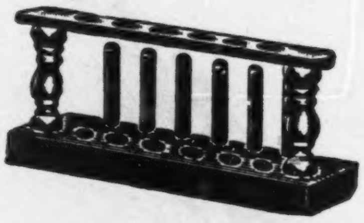
Test Tube



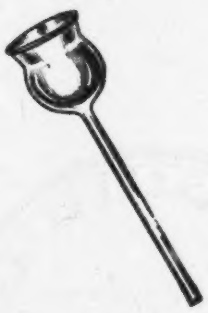
Test Tube Brush



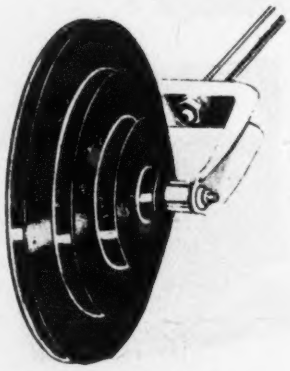
Test Tube Clamp



Test Tube Support

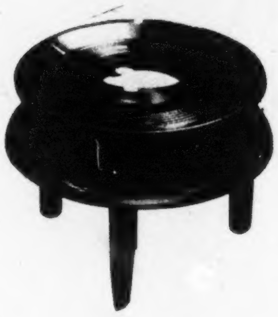


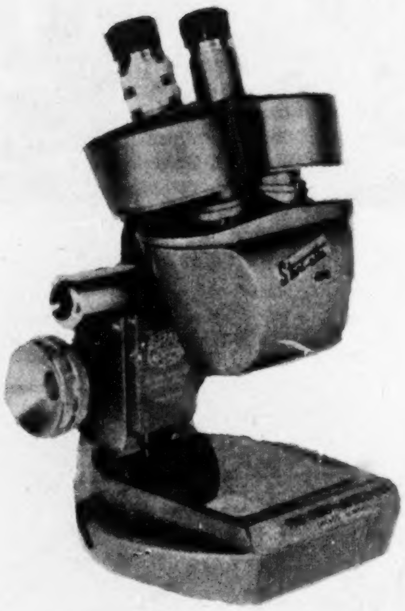
Thistle Tube



Wheel and Axle

Microscopes





What kind of optical equipment should schools use in the elementary grades? It seems as if the student should not begin with a high power compound microscope. It also seems that the students' ability would determine what instrument to use.

The young student should start with a single lens type of magnifying glass. He would learn and understand magnification. He would understand what is meant by ten power, one hundred power and four hundred power. The next step in the grades would be to use the stereo microscope with magnification of, generally, ten to thirty power. The stereo microscope enables a student to view an object in three dimension which is a more natural state for the child, and he can look with both eyes. An illuminator built into the stereoscope has advantages.

The stereoscope, sometimes called a dissecting microscope, can be used to look at opaque objects, for low power work, and objects too large for the compound microscope. Some things that can be examined with the stereoscope are various kinds of cloth, fingernails, sand, clay, various rock and minerals, wood, crystals of salt, sugar, etc., insects, animal parts, flowers, parts of plants, coins and feathers. Cells and microscopic animals require the use of a compound microscope.

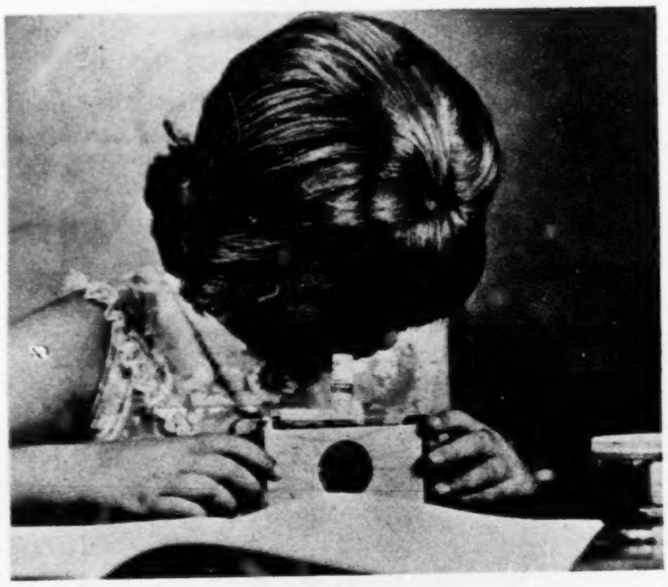
After the student has become familiar with the hand lens and the stereo microscope, he should be introduced to the use of a compound microscope with two or more objectives. The microscope should have an electric illuminator so as to eliminate the problem of adjusting a mirror and the problem of enough available light. The instructor must be sure that the student understands the operation and the care of the microscope before he is assigned to use it. Biology laboratory manuals are good resources on the microscope. There should be several microscopes for a room. The compound microscope is generally used for study of cells and microscopic plants and animals. Light must be able to penetrate through the specimen.

The sequence then would be hand lens,

stereo microscope, and compound microscope. When to use an instrument would be determined by the student's background and ability. There should be some work with the compound microscope in the seventh grade "Life Science" course. In biology a student should become adept with the use and care of all these optical instruments.

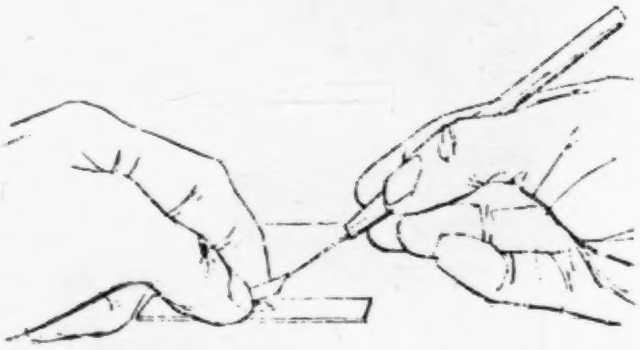
The micro-projector has found its use in many classrooms. It will project slides and small specimens which require great magnification. Groups of students or, in some cases, the entire class may view the slide or specimen at the same time. It provides for group participation and reaction.

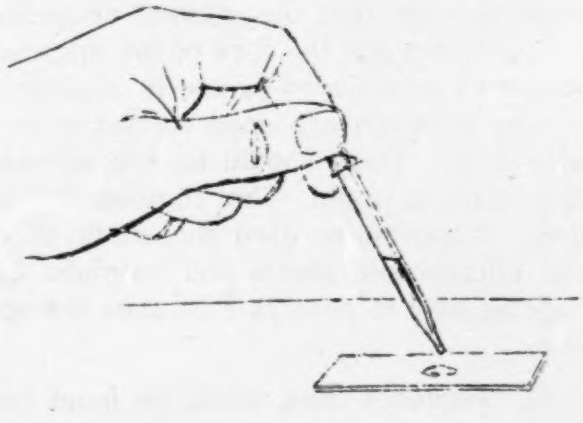
Small, inexpensive microscopes have been developed by some of the National Curriculum Studies, such as the Elementary Science Study, that have proved adequate for their units. The magnification and clarity of the lenses in these inexpensive microscopes is generally satisfactory for the type of visual exploration required. They also help children to understand the workings of the more sophisticated instruments. In addition to these inexpensive microscopes, it is desirable to have the more "professional" compound microscope available for in-depth investigations.

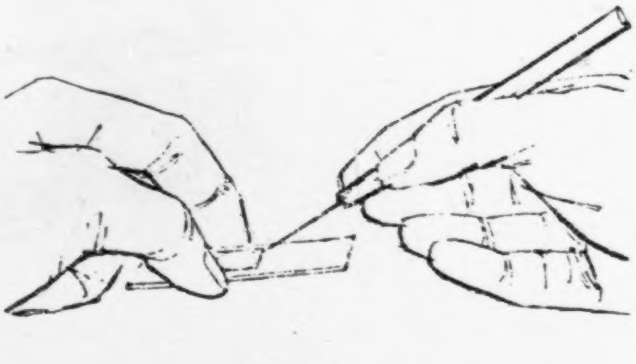


How to Prepare a Slide

1. Use clean slide and cover glass.
2. Put your specimen on the slide.
3. Very carefully add a single drop of water.
4. To cover the specimen with a cover slip, touch one edge of the cover slip to the drop of water, then gently lower the cover onto the specimen. Keep the bottom of your slide dry.



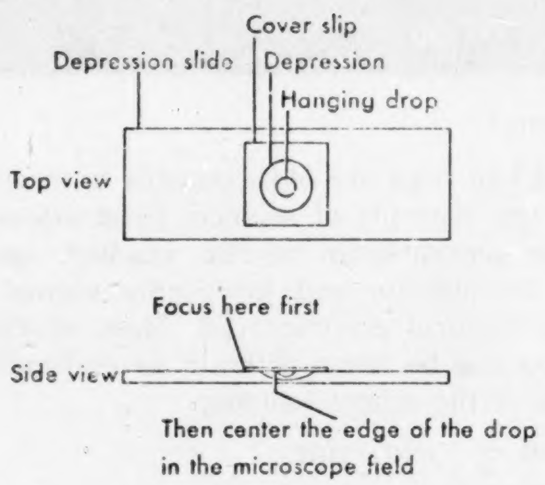


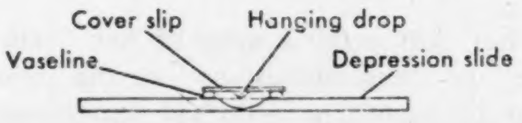


How to Prepare A Hanging Drop Slide

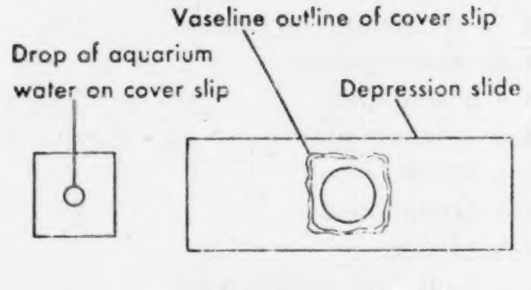
A drop of the liquid containing the specimen is placed on a cover glass. This drop then hangs in the cavity of a depression slide. See the diagram. See also the diagram using vaseline.

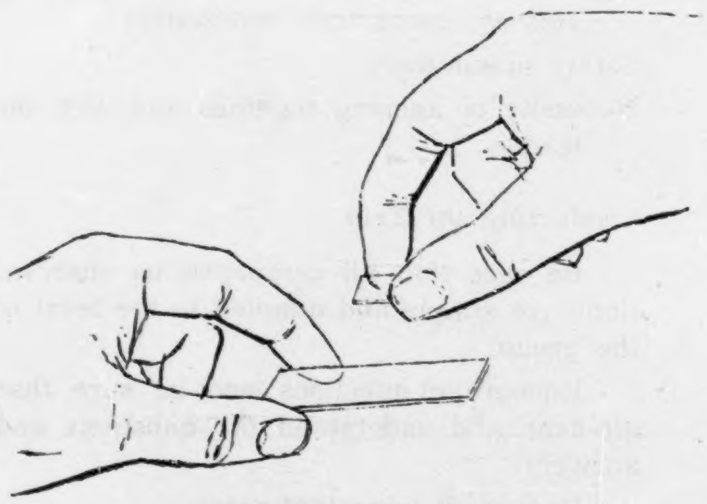
There may be some difficulty in finding the drop through the microscope. The following procedure will help: Use low power and focus first on the edge of the cover slip. Then move the slide over until you are looking at the drop and adjust the focus.

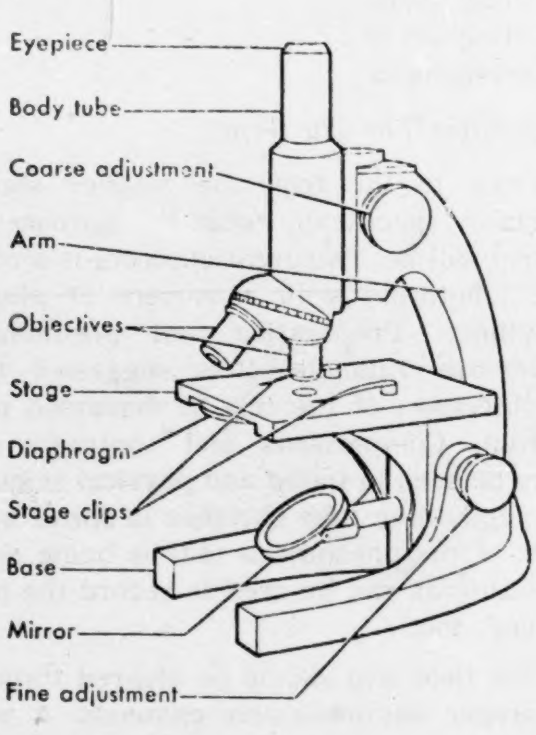

Cover slip
Depression slide
Depression
Hanging drop
Top view
Focus here first
Side view
Then center the edge of the drop in the microscope field


Cover slip
Hanging drop
Vaseline
Depression slide

Cross section of hanging drop preparation


Vaseline outline of cover slip
Drop of aquarium water on cover slip
Depression slide




Eyepiece
Body tube
Coarse adjustment
Arm
Objectives
Stage
Diaphragm
Stage clips
Base
Mirror
Fine adjustment

Field Trips

General

Field trips are indispensable in developing the concepts of science. Illustrations of these concepts can be felt, smelled, touched, listened to, and thoroughly viewed in their natural environment. Most of these things can be found within a several-minute walk of the school building.

Types of Field Trips:

Walk along a nature trail
Study the ecology of an area
Visit to a zoo
Visit a telephone company
Visit a water plant
Visit a newspaper
Visit a sewage plant
Visit a mine
Visit a greenhouse
Visit a garden
Visit a food processing plant
Visit an industrial plant
Visit a pet shop
Observing trees
Observing birds
Observing insects
Observing flowers
Observing rocks and formations
Observing erosion
Collecting insects
Collecting leaves
Collecting plants
Collecting buds
Collecting seeds
Collecting rocks

Preparation For The Trip

Prior to the trip, the teacher should determine specifically what the purpose for the trip will be. The great outdoors is a complete laboratory with a variety of almost everything. Preparation and preliminary studies are valuable. It is suggested that the objectives of the trip be discussed with children. Comparisons and contrasts can easily be seen in living and physical science. The pupils may take sketches in spiral notebooks of the phenomena that is being studied. Cameras can be used to record the phenomena, too.

The field trip should be cleared through the proper administrative channels. A wise teacher will send a copy of her "trip purpose" or "trip objectives" to the principal prior to each trip. Planned experiences as field trips should be part of the teacher's lesson plans. In some cases it may be necessary to secure parents' permission.

Preliminary Instructions

Purpose of trip and destination
Time of departure and return
Appropriate clothing (jackets, rubbers, etc.)
Some specific things to observe, collect, or discover
Equipment needed, if any, (magnifying glasses, containers, notebooks)
Safety precautions
Necessity of keeping together and with the leader

Conducting the Trip

Be sure that all comments on observations are simple and adapted to the level of the group.

Encourage questions and be sure that all hear and understand the questions and answers.

Repeat all important points.

Give more than facts and names; if possible, present "human interest" information about items seen.

Make the most of unexpected occurrences and observations volunteered by the group.

Emphasize the relationship or principles of ecology to conservation, to life processes, foods, and classifications when possible.

Summary of the Trip

Discuss the highlights and important findings. This is properly done on the spot after observations have been made and relationships pointed out.

When the ground is dry, pupils can be seated comfortably in a circle. If a particular area of the school grounds is frequently used for field trips, it may be possible to provide several logs to sit on or picnic table benches for the summarizing session.

If necessary, the summary can be made in the classroom immediately on returning. The important thing is that the trip should be so timed as to provide opportunity for a summary.

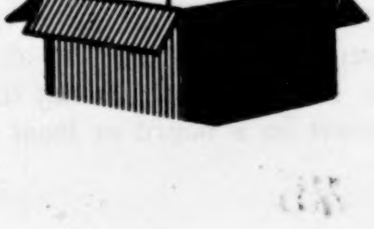
How to Make a Demonstration Incubator

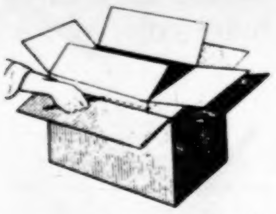
Supplies needed:

Two cardboard boxes: one - 16 inches wide by 20 inches long by 12½ inches high; one - 14 inches wide by 18 inches long by 13 inches or more high; double strength pane of glass 16" x 20"; one-fourth inch welded hardware cloth 18" x 22"; heating unit - commercial unit or porcelain socket and light bulb cake tin (water pan) 1½ inches deep by approximately 9" x 14"; sharp knife or large scissors; yardstick; tin snips; screwdriver; glue; pencil; masking or Scotch tape; newspaper or other insulating material; one brooding or incubator thermometer and one wet bulb thermometer.

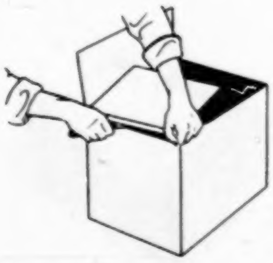
The equipment and supplies described are for a standard 16 x 20 inch still air incubator. If you wish to make a larger incubator, remember that the inside box should be about 2 inches shorter and 2 inches narrower than the outside box. Remember, also, that the inside box should be higher than the outside box. If you make a larger size incubator, the glass and the welded hardware cloth need to be cut to fit.

Step 1. Place the smaller box inside the larger box.

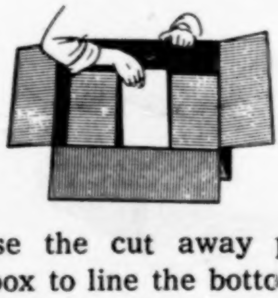




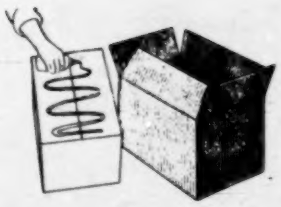
Step 2. Make a mark about ¼ inch below the level of the outside box on all four sides of the inner box. Mark a straight edge around all four sides of the inner box after it has been removed.



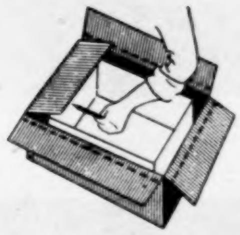
Step 3. Cut off top of inside box along the lines made in Step 2.



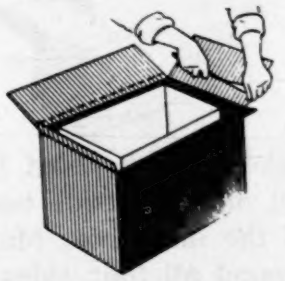
Step 4. Use the cut away pieces of the inside box to line the bottom of both the inner and outer boxes where the flaps do not meet. If the pieces are not large enough, cut pieces to fit from a third box.



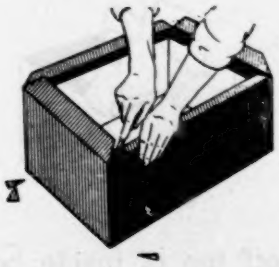
Step 5. Put glue on the bottom of the inner box and then center inner box on the outer box leaving the same amount of space between the two boxes on all four sides. Weight down inner box until the glue dries.



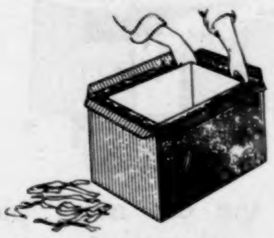
Step 6. Mark a line on the flaps of the outside box where they come into contact with the inner edge of the inside box.



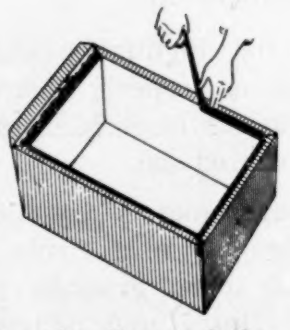
Step 7. Cut off flaps of outside box along lines drawn with a straight edge in Step 6.



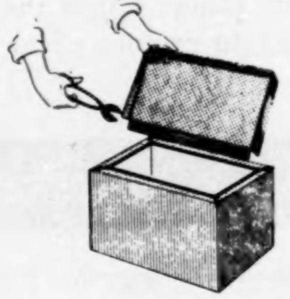
Step 8. Cut corner pieces on the diagonal so they will fold down to form a neat, flat corner.



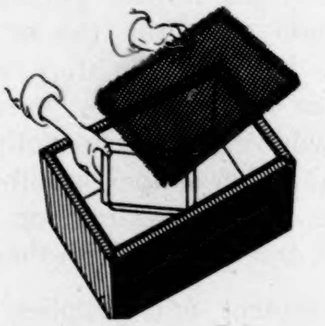
Step 9. Insulate the space between the boxes with strips of newspaper, excelsior, wood shavings, styrofoam or some other insulating material.



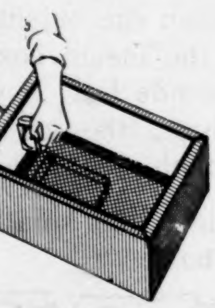
Step 10. Tape the flaps of the outer box to the top edge of the sides of the inner box. This seals the area in which the insulating material was placed.



Step 11. With a tin snip, cut a 2-inch square from each corner of the piece of hardware cloth. Then bend the projecting pieces so they form legs to support the hardware screen as it rests on the bottom of the inside box.

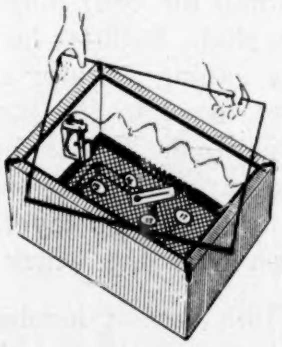


Step 12. Place the metal pan, which will cover about 1/3 of the surface area of the inside box, under the hardware screen.



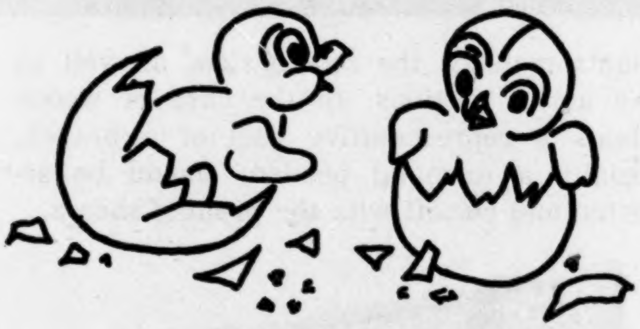
Step 13. If a commercial heating element is used, install it according to the directions sent with the unit. If an electric light is used for heat, mount the porcelain socket on a board at least 6 inches

square. Now place the mounting board on the screen. Next a tube of cardboard, like a chimney, should be placed around the light. An oatmeal box makes a good tubular chimney. The tube should not come into contact with the pane of glass that covers the incubator. Wire all of the electrical units as directed in the 4-H club electrical project instructions.



Step 14. Before setting any eggs, put water into the water pan. Place a thermometer on a small block of wood so that the bulb is about 1 inch above the screen. Cover the edges of the pane of glass with masking tape and then place on the incubator. Run the incubator until it holds a temperature between 97 degrees F. and 103 degrees F.

The commercial unit is controlled by an adjustable thermostat. If a light bulb is used, the heating unit is controlled by the size of the opening made by moving the pane of glass back from the edge of the incubator. The wattage of the light bulb will also vary the temperature. A 25 watt light bulb should be tried first.



HATCHING CHICKS IN A STILL AIR INCUBATOR

Life inside the shell of a chicken egg is one of nature's wonders. This is the home of a baby chicken for the first 21 days of its life. It also contains the food supply during this time. The yolk and white of the egg contain all the proteins, carbohydrates, minerals and vitamins necessary for the embryo to grow into a chick. Scientists have discovered many fundamental facts about life by studying the development of the chick embryo.

Care of the Eggs Before Incubation

The structural development of the chick embryo starts by a single cell dividing to form two cells on the surface of the yolk. Cell division continues during the 24 to 26 hours that it takes for formation of the egg in the oviduct. When the egg is laid, the young embryo consists of 4,000 to 6,000 cells. At this point cell division ceases if the temperature surrounding the egg is less than 80 degrees F.

Hatching eggs should be packed in the case large end up. They should be sorted 55 to 60 degrees F. The humidity should be in the 75 - 85 per cent range.

Holding eggs at too high or too low temperatures and humidity can reduce hatchability. Keeping eggs at 32 degrees for 3 days may destroy their ability to hatch. On the other hand, eggs stored at 90 degrees for 5 to 7 days may also hatch poorly.

For best hatchability, eggs should be set within 7 days after they have been laid.

Using the Still Air Incubator

When you start a cardboard still air incubator, it should be operated with water in the pan for several hours before the eggs are placed in the incubator.

During the warm-up period, the temperature should be approximately 100 degrees F., a level of 1 inch above the wire screen. The temperature can range from 97 degrees to 103 degrees F. with no harmful effects. However, if it stays at either extreme, 97 degrees or 103 degrees F. for several days, the hatch may not be good.

Fertile eggs can take a certain amount of abuse because they are well insulated and protected but they are sensitive to extreme heat. If you run the incuabtor at 105 degrees for ½ hour, it will seriously affect the embryos. However, running at 90 degrees for 3 or 4 hours will merely slow the embryo metabolic rate.

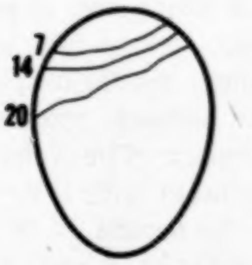
Before setting the eggs, mark the date on one side of each to serve as a record of the day set and to act as an indicator as to time of turning the eggs. Best results are obtained when the eggs are placed directly on the screen.

The eggs must be turned at least three times a day. Turn the eggs early in the morning, after school and the last thing at night. If there is a long period of time between two of the daily turnings, the side that is up the longest should be staggered from day to day. It is not necessary to turn the eggs during the last three days of incubation.

Humidity in the incubator should be from 50 to 55 per cent the first 18 days and 65 to 70 per cent the last 3 days. If you use a wet bulb thermometer, you can determine the relative humidity from the following chart:

Temp. °F.	*Wet Bulb Reading in Still Air Incubators*					
100	81.3	83.3	85.3	87.3	89.0	90.7
101	82.2	84.2	86.2	88.2	90.0	91.7
102	83.0	85.0	87.0	89.0	91.0	92.7
Relative Humidity %	45	50	55	60	65	70

As incubation progresses, the air cell of the egg becomes larger because of loss of moisture by the egg. The following drawing shows the normal size of air cells at 7, 14 and 20 days of incubation:



Low humidity, or excess drying (a large air cell) causes the chick to stick in the shell. Insufficient drying because of extra high humidity (small air cell) may suffocate the chicks in the shell. Relative humidity can be increased by adding a water soaked sponge or small wet towel to the incubator or by using a larger pan. It can be reduced by using a smaller pan, by opening the glass cover, or putting several layers or crinoline on the screen over the water pan.

On the 18th day of incubation, place a layer or two of crinoline cloth in the wire screen. This provides a suitable hatching surface for the chicks and reduces the possibility of injury. When the eggs hatch, remove the chicks as soon as they are dry. Place the chicks under a hover with the temperature adjusted to 95 degrees F. and give them feed and water immediately. It may be necessary to dip each chick's beak in the water to help the chick find the water.

The cover of the incubator is an ordinary pane of glass. The glass provides for observation of the embryo and opened eggs and chicks at hatching time.

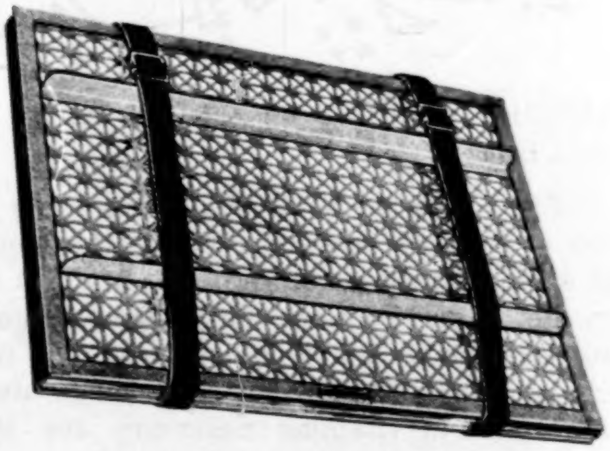
How to Make a Plant Collection

A collection of well-preserved and accurately identified plants is a valuable aid to the elementary teacher.

Several points must be observed in making a good collection. The plants must be dried quickly for good color retention and they must be dried under pressure to prevent wrinkling.

Plants which are average in size, reasonably complete, and relatively free of insect or other damage are preferred. Since classification and identification are largely based on the reproductive parts, especially in flowering plants, it is highly desirable to select plants which bear these.

A complete specimen of herbaceous plants includes the root system as well as the aerial portions. In the case of woody plants a representative part of a branch, usually a terminal portion, should be selected and cut off with the pruning shears.



Taking notes at the time the collecting is done is necessary. Each plant should be checked as to flower color, odors present, and other data which may be lost in drying. Also, ecological conditions of the area should be briefly noted. Finally, the date, locality, and name of the collector should be recorded.

Each plant should be assigned a reference number which is entered in the book. A small piece of paper bearing the same number should be placed with the specimen and kept with it during its subsequent processing.

A folded half-sheet of newspaper serves to hold each specimen while it is drying. When the plant is placed in the paper, the leaves should be arranged so as to show the underside of at least one leaf and the upper sides of others. Flowers should likewise be arranged. (After the plant is dry, attempts to arrange it usually result in breaking the specimen.)

After a satisfactory arrangement is made, the folded half-sheet of newspaper containing the plant is placed between two botanical driers (sheets of blotting paper) to absorb moisture from the specimen. This is then placed between corrugated cardboard. The ribs of the corrugation should be in contact with the blotters to permit the air to reach the latter.

When all of the plants have been thus prepared they are stacked and placed between the panels of the plant press, and the straps tightened securely. Rapid drying is desirable because color is retained better.

Once the plants are well dried they can be left in the folded newspapers and stored in boxes. However, to permit freer handling, mounting on standard 11½" x 16½" tagboard sheets is recommended. The plants are fastened to the sheets with a good glue or herbarium paste. To apply adhesive, take a sheet of glass or smooth metal about the size of a herbarium sheet or larger and brush a thin layer of glue over the entire surface. Carefully lay the dried plant on the glue making sure that all parts are in contact with it. Then carefully lift the plant and lay it on the herbarium sheet in the exact spot where it is to remain. (Attempting to apply glue directly to the plant by brushing it on usually results in a damaged specimen or a messy mount.)

For especially heavy or stiff, woody specimens, small strips of gummed tape can be used to provide secure attachment of the stems. Even in this instance, the use of glue or paste is recommended to fasten the leaves tightly to the sheet.

A label should be attached to the lower right corner of the herbarium sheet. Information to be included on it is:

Plant family
Name of plant (scientific and common)
Where collected
Date collected
Name of collector
Miscellaneous (ecological data, etc.)
Reference number

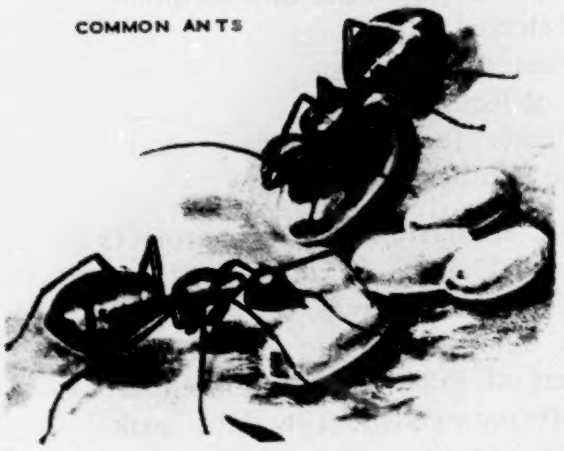
Storage in herbarium folders protects the specimens. The stacks of folders can be placed in boxes, on shelves, or best of all, in a cabinet. Since insects do attack dried plants, the use of moth crystals or similar repellent is recommended. The data book, which usually contains more information about the plants than is recorded on the sheets, should be kept with the collection.

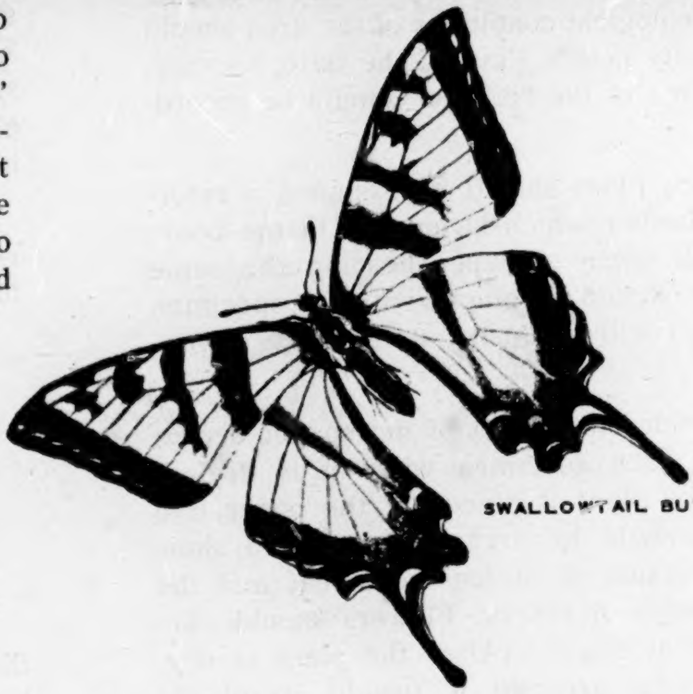
Fleshy fruits (berries, etc.) can be preserved in 4 per cent formalin and kept in jars of the preservative. Dry fruits such as nuts can be stored in envelopes or boxes. Fruit which has been removed from a specimen mounted on a herbarium sheet should be given the same reference number as the sheet in order to identify the source plant.

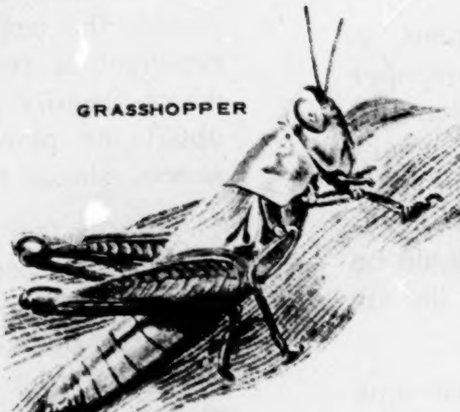
The Prairie Rose, our state flower.

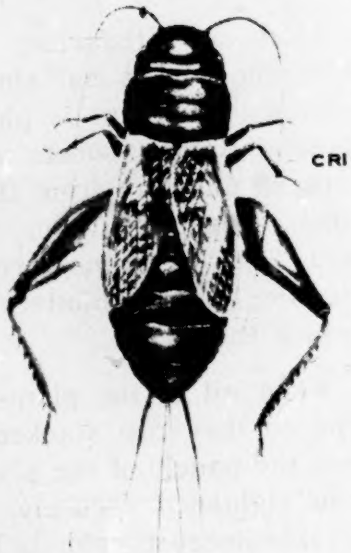
How to Make a Collection of Insects

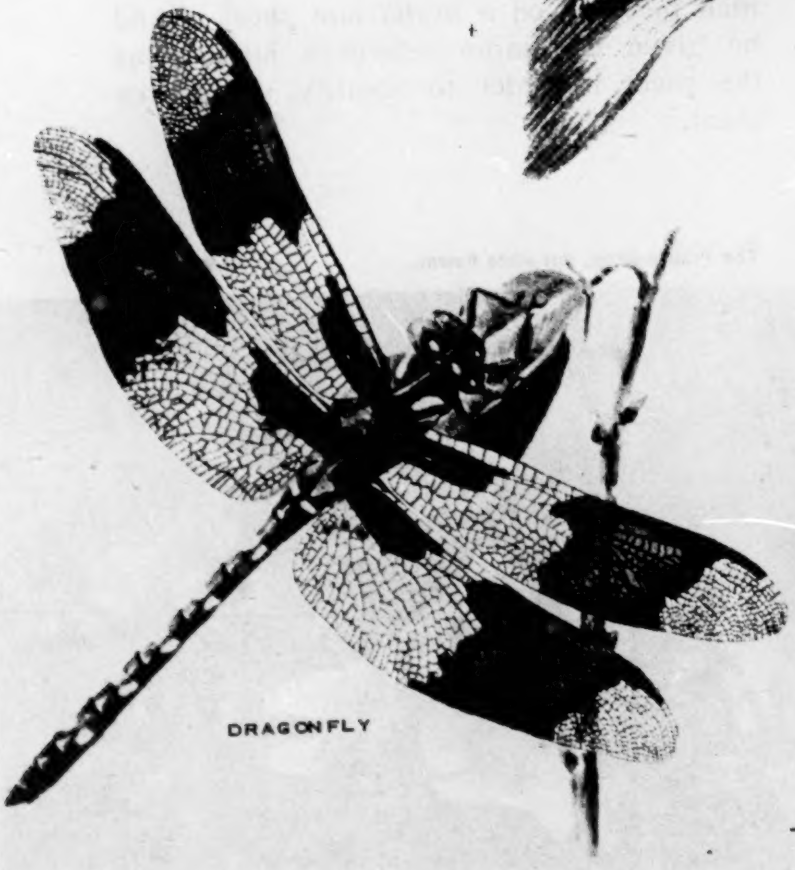
Insect collecting is very interesting to many students and the booklet, "How to Make a Collection of North Dakota Insects," published by the Department of Public Instruction, has been sent to all schools. Insect collecting could become a hobby for the whole family. The booklet describes how to collect, kill, mount and classify. Very good for the beginner.

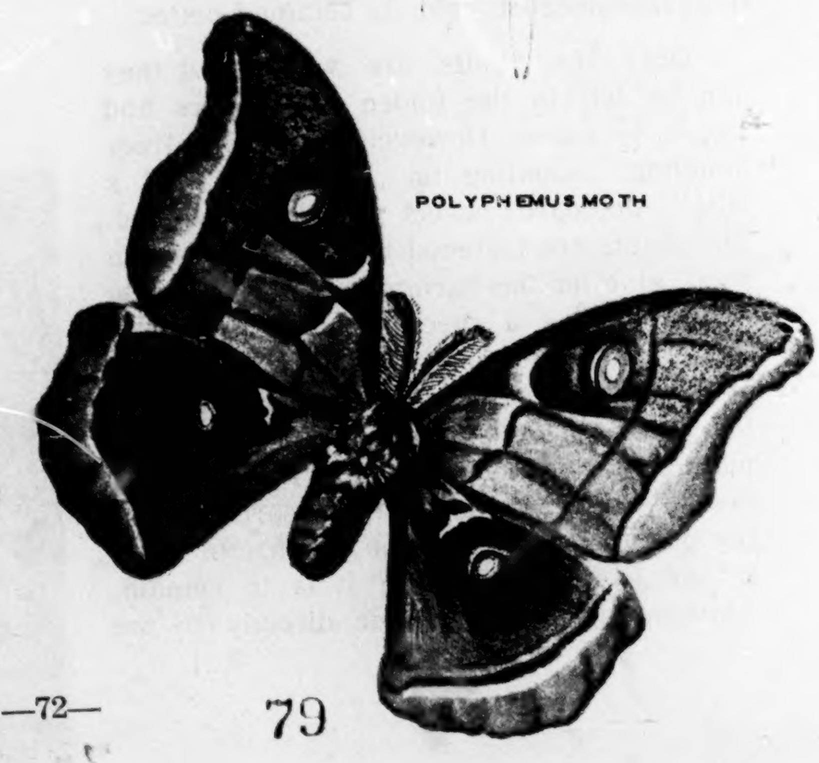

COMMON ANTS


SWALLOWTAIL BUTTERFLY


GRASSHOPPER


CRICKET


DRAGONFLY


POLYPHEMUS MOTH

Working with Graphs

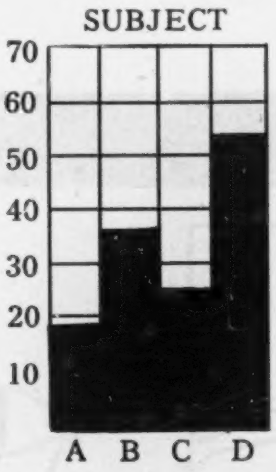
Graphing

A very useful technique to illustrate information is graphing. Actually, any picture or diagram may be considered to be a graphical representation but in this bulletin only those graphs which represent numerical information will be considered. By presenting information through a graph,. children can easily recognize trends and make reliable predictions just as the professional scientist does.

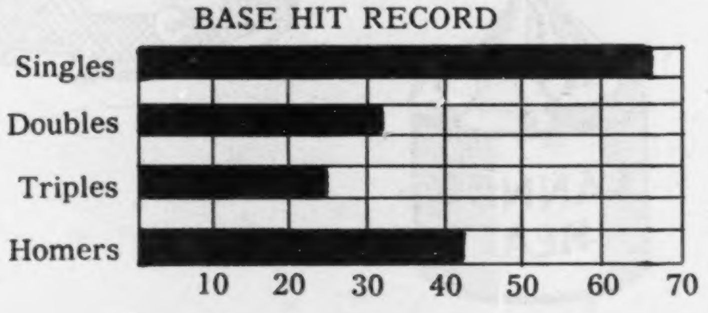
Bar Graphs

Changing conditions are easily illustrated by the bar graph. Not only do bar graphs show changes but they are very simple to construct.

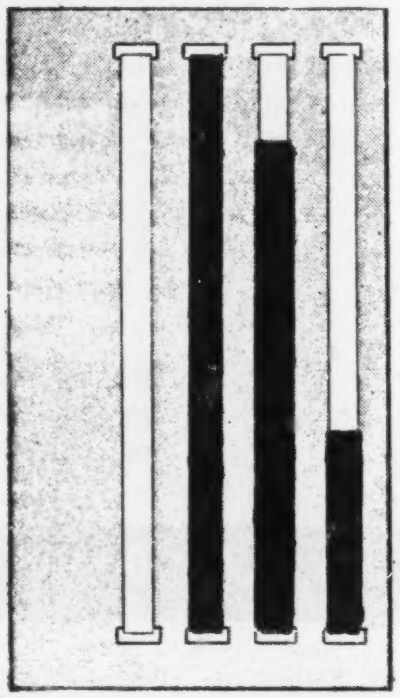
1. The "drawn" bar graph. In this type of graph the proper length bars are drawn on the paper. For increased attraction and interest the bars can be colored in so that they contrast with the background.



2. The "cut-out" bar graph. This type of graph is constructed by cutting the bars out of colored paper and pasting them on a paper background.

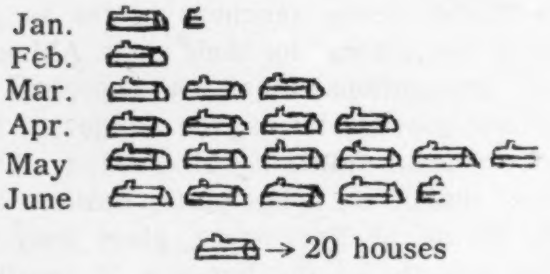


3. Adjustable bar graphs. By cutting a slot in the background paper, it is possible to pass long paper bars through them and pull the bar out to any desired length. If such a graph is mounted on a bulletin board, a thumbtack will hold the bar in place. The advantage of the adjustable graph is that it can be easily and quickly changed. The disadvantage is that, once changed, previous information is no longer recorded.

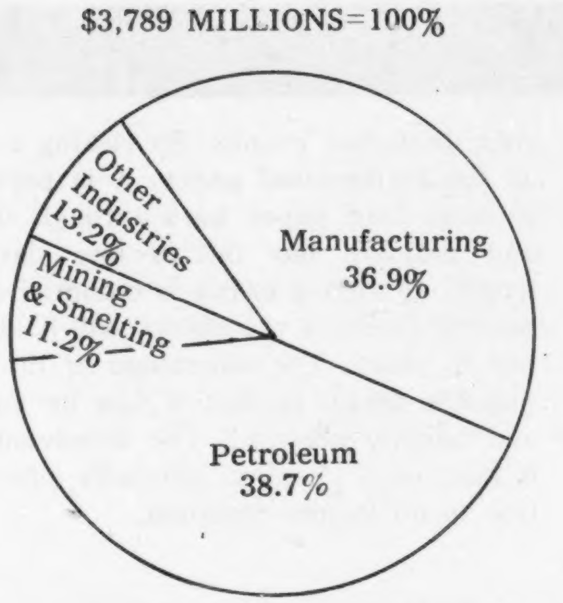


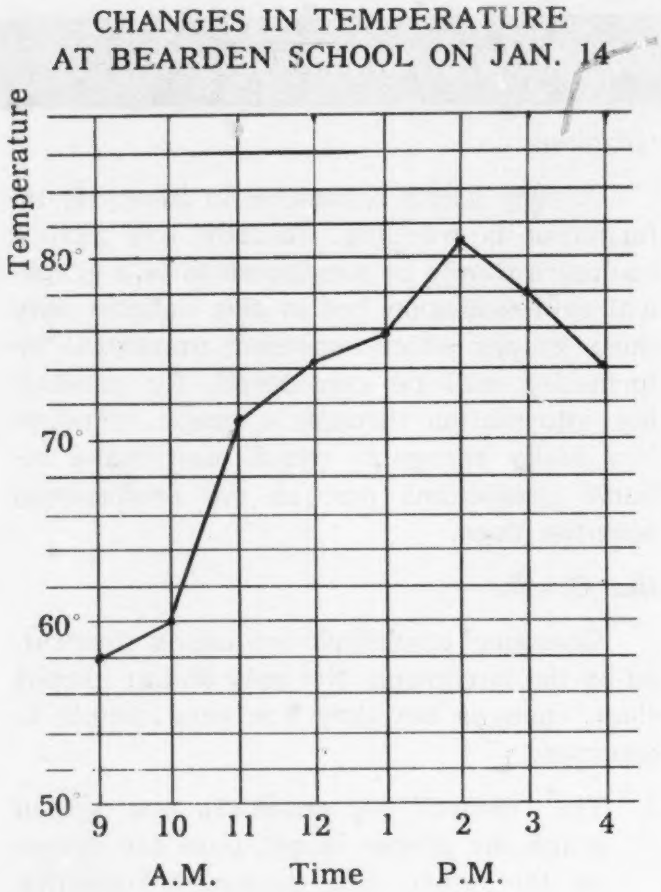
A picture graph or pictograph is especially designed to catch the eye. Each figure in a line represents a certain number.

HOUSE CONSTRUCTION
PERMITS ISSUED IN A CITY
FOR THE FIRST HALF OF A YEAR



Circle graphs are used to represent parts of a whole.





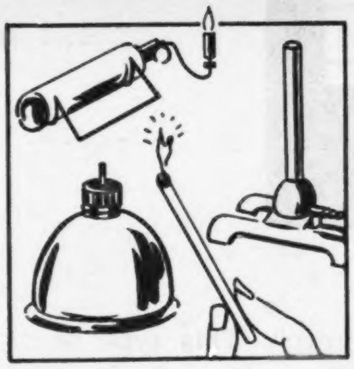
Line graphs are often used to represent numerical facts such as a series of readings on a thermometer.

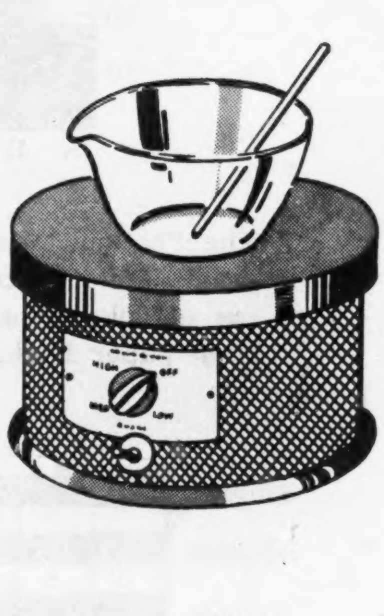
Students should have practice in making graphs as a result of an experiment and they should receive practice in reading and interpreting graphs.

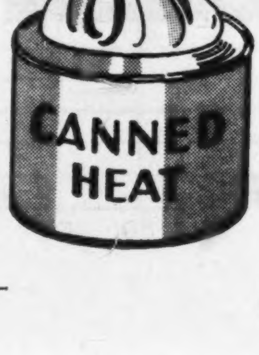
Working with Heating Devices

Cans of solidified alcohol or canned heat can be purchased. To operate these heaters the lid is removed and a lighted match is brought to the surface of the alcohol. To extinguish the flame the cap is simply replaced on the can. Some care should be taken as the top of the can will get hot while it burns.

Since many science activities which require heat do not necessarily require an open flame, many teachers prefer to use electric "hot plates" for their class. Although safety precautions must be exercised to eliminate possible burns, the danger of fire from an open flame is eliminated. When heating liquids on a hot plate, beakers and flasks made of Pyrex-type glass may be placed directly on the burners. If possible, the heater should be equipped with an on-off switch so that it will not be necessary to pull the wall plug out after each use.







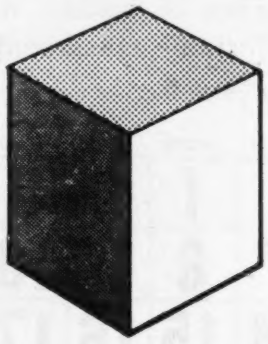
Candles as a rule are not satisfactory for heating and should be used only in activities specified. A teacher should use extra precautions with an open flame around children and very close supervision must be observed if children are to use the flame. Bunsen burners are usually not available, but if they are a teacher should light them and place them in a position where children will not burn themselves or their clothes. Alcohol lamps are not as safe as cans of solidified alcohol.

Propane burners may be used by the teacher (not the students) if hotter temperatures are necessary. If a teacher is not familiar with heating devices, he should learn all about using it before he tries it in the classroom.

Working with Measuring Instruments

Volume

Volume is closely related to the measurement of distance since volume of certain objects (blocks, boxes, etc.) can be determined by multiplying the object's height by its length by its width.



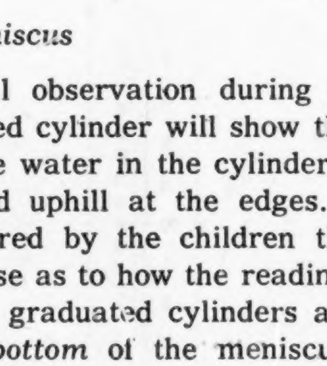
Volume of cubes or rectangular solids

The three dimensions of a block or box can be measured directly with a ruler, but the product of these three numbers must then be calculated. This is an exercise that makes one of the advantages of the metric system immediately apparent. Since most rulers divide inches into sixteenths, multiplication of the three dimensions becomes difficult.

500
450
400
350
300
250
200
150
100
50

Volume of liquids

Because liquids have no permanent shape it is necessary to use some other instrument than the ruler for determining their volume. Measuring containers are available for both the English and metric systems. With ordinary measuring cups children can measure the capacity of various bottles, jars, and plastic containers. They may be surprised to discover that the tallest bottles do not necessarily hold the most liquid. During the intermediate grades the children should become familiar with the graduated cylinder which is calibrated in units of milliliter. By determining the capacity of a soda bottle in both the English and metric systems, it becomes readily apparent that milliliters are much more convenient units to work with than ounces, cups and pints.

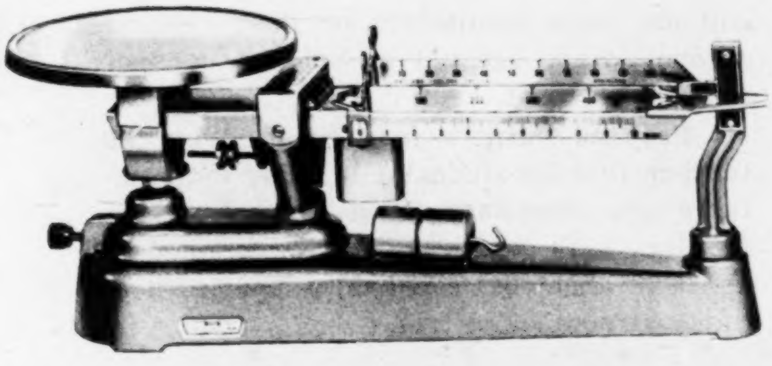


The meniscus

Careful observation during the use of a graduated cylinder will show that the surface of the water in the cylinder is not flat, but curved uphill at the edges. When this is discovered by the children the question should arise as to how the reading should be made. All graduated cylinders are made so that the *bottom* of the meniscus or curve should be read.

Weight

Weight is a measure of the pull of gravity on an object. Since the force of gravity



is different on different objects, weights vary. Young children learn to generalize that large objects tend to weigh more than smaller ones, but as their experience increases it becomes apparent that such a simple generalization does not always hold. For instance, a pillow may be larger than a quart of milk, but weighs considerably less. Just as one length can only be measured by comparing it to some other length, weight, too, is determined by comparing to some standard weight.

During their elementary years, pupils should develop an understanding that units of weight, like units of length and volume are arbitrary amounts which have been universally accepted by man for covenience sake.

In our everyday lives we use the pound and ounce, but the fact that there are 16 ounces in a pound makes calculations very awkward, so the scientist uses grams, and tenths of grams, for convenience. Actually, children can make all their measurements of weight in terms of pennies or paper clips or marbles. Any standard will do. Spring scales and balances should be available for students to weigh things. Handle balances with care.

Temperature

Temperature, that is hotness or coldness (not heat!), is measured with a thermometer. The scientist uses the Centigrade (or Celsius) scale because it is much more convenient than the Fahrenheit scale. The teacher may prefer to work with the Fahrenheit scale because of the pupils' familiarity with it.

The Fahrenheit scale

The Fahrenheit scale has been established so that the temperature of freezing water is 32 degrees and the temperature of boiling water is 212 degrees. On this scale our outside air seldom gets colder than twenty degrees below zero or hotter than 100 degrees. A comfortable classroom is approximately 70 degrees.

The Centigrade scale

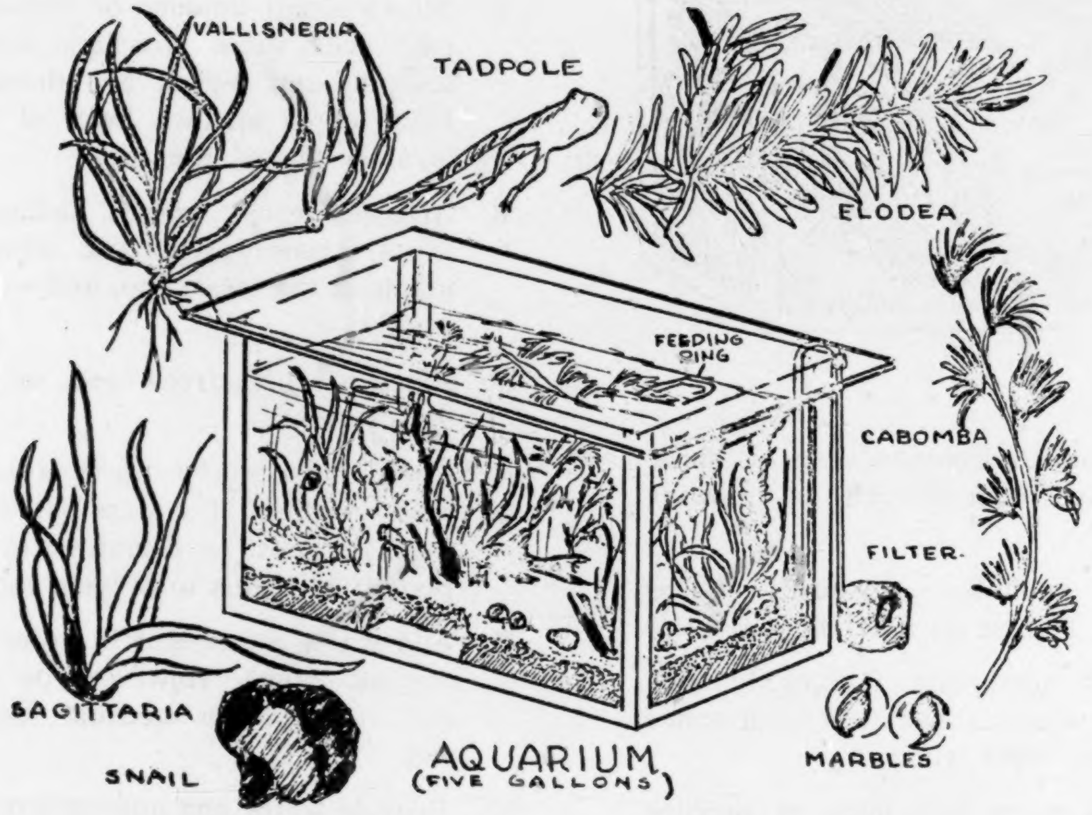
On the centigrade scale zero marks the temperature of freezing water and 100 marks the temperature of boiling water. By this scale a comfortable classroom temperature is about 23 degrees.

SUN
MON
TUE
WED
THU
FRI
SAT

Time

The measurement of the passage of time is the key measurement to be made any time a scientist is studying a changing situation. When studying falling objects, or the rate of a plant growth, or the reaction time for chemical processes, time must be measured. The geologist measures time in terms of millions of years; the biologist measures growth in terms of days or months; the physicist often measures events which take place in small fractions of a second. During the course of an elementary science program the children should undertake activities which require the measurement of time.

Preparing and Maintaining Fresh-Water Aquarium

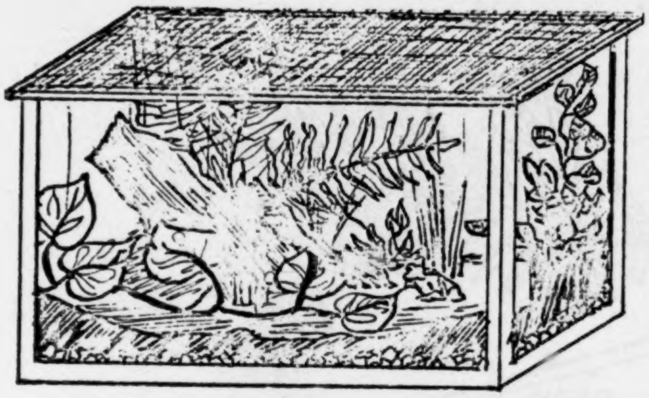


PREPARING AND MAINTAINING A FRESH-WATER AQUARIUM

The following steps will assist in developing and maintaining a fresh-water aquarium:

1. Have access to the necessary equipment. This includes a tank, filter, plants (anarcharis, cabomba, vallisneria), a dip net, sand, fish, snails, and food.
2. Wash the tank thoroughly with soap and water. Rinse it several times to remove soap and to insure cleanliness. Fill the tank and allow it to stand for about a day to provide additional cleansing and to provide a check for leaks.
3. Wash the sand with several rinsings in boiling water. Put about one inch of the clean sand in the bottom of the tank.
4. Lay a large sheet of paper on top of the sand before adding water. This prevents the water from stirring the sand.
5. Add water to within about an inch or two of the top. If tap water is used allow it to stand for a couple of days to permit the chlorine to escape from the water.
6. Add water plants along with water from which they were obtained.
7. Add a few rocks to provide a hiding place for the animals.
8. Provide about two snails for each gallon capacity of the tank.
9. Place in a position of indirect lighting. Avoid direct sunlight.
10. When adding new fish, float fish container in water until the fish water and aquarium water are at the same temperature.
11. Feed regularly. Avoid overfeeding. Clouding of water may indicate overfeeding.
12. Add water as needed.
13. Remove excess food, dead animals, and dead plants.

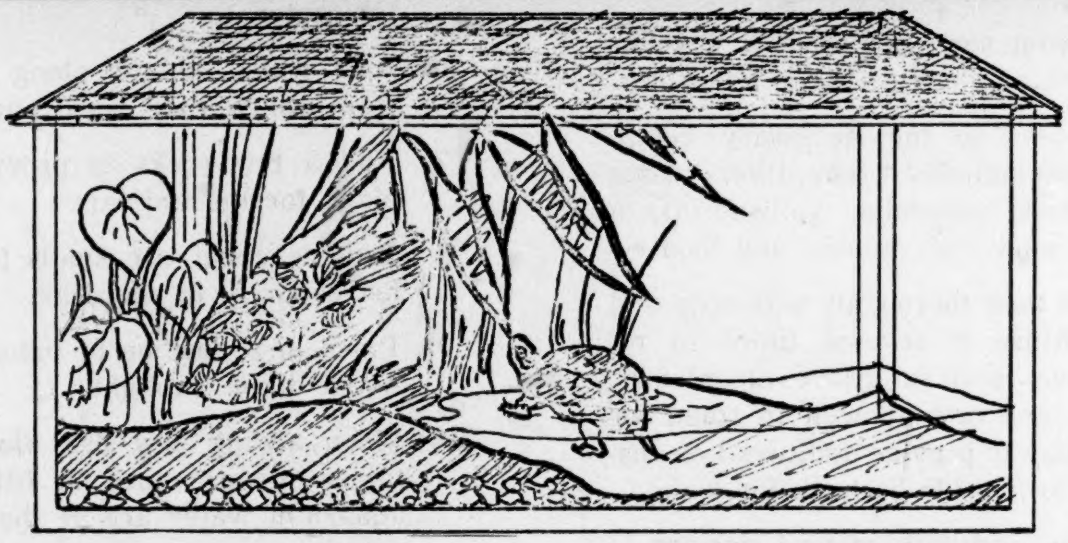
Preparing and Maintaining a Woodland Terrarium



A woodland environment can be simulated in the classroom through the following procedures:

1. Locate a suitable, water-proof, glass container for use as a terrarium.
2. Wash the terrarium thoroughly with soap and water. Rinse it several times with clean, clear water.
3. Place about an inch layer of pebbles on the bottom of the terrarium.
4. Place about an inch of sand on top of the pebbles.
5. Mix a small amount of crushed charcoal with some woodland soil which contains soil, twigs, and dried leaves. Place about an inch layer of the mixture on top of the sand.
6. Arrange ferns, mosses, lichens, liverworts, wintergreen, and other forest plants in the terrarium, and water thoroughly.
7. Place a snake, frog, newt, or turtle in the container.
8. Cover the container with a screen or plate of glass. If a glass cover is used, fresh air must be permitted to enter at regular intervals to prevent mold.
9. Add water as needed in order to keep the soil moist. However, do not permit the soil to become excessively wet.
10. Provide water and appropriate food for the animal kept in the terrarium.

Preparing and Maintaining a Semi-aquatic Terrarium



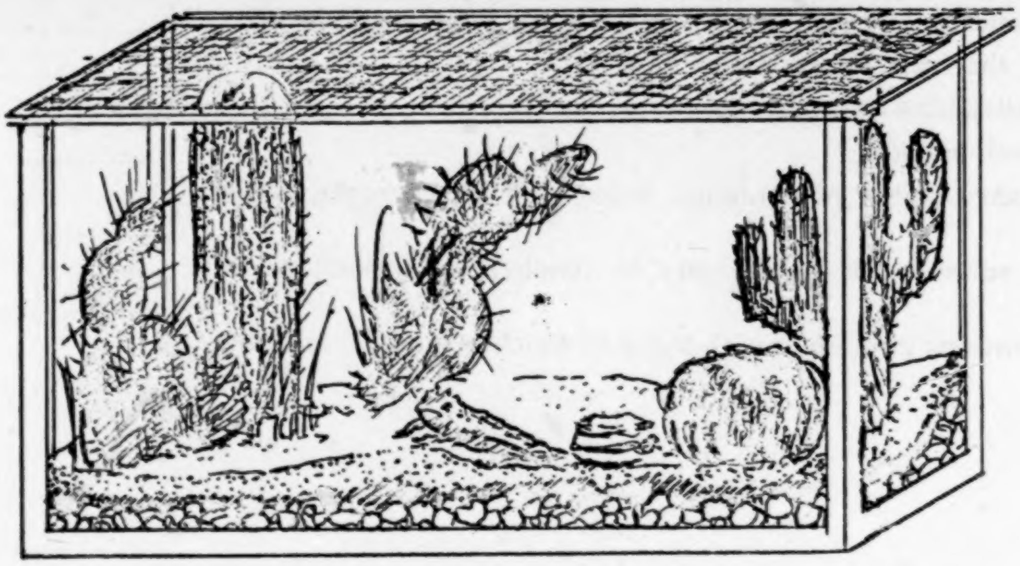
A shoreline environment can be simulated in the classroom through the following procedures:

1. Locate a suitable, leakproof, glass container for use as a terrarium.
2. Wash the terrarium thoroughly with soap and water. Rinse it several times with clean, clear water.
3. Prepare a layer of pebbles about an inch deep on the bottom of the container.
4. Using pebbles and sand, build up one end of the interior to about one half the height of the container.
5. Cover the built up area with soil.
6. Plant such things as mosses, ferns, arrowhead, partridge berry, wintergreen

berry, lichen, liverworts, and creeping Charlie in the soil on the raised portion.

7. Pour water in the shallow end of the container until a pond is created which takes up about half of the terrarium.
8. Place a turtle, salamander, frog, toad or crayfish in the container.
9. Put a glass cover on the container.
10. Provide water and appropriate food for the animal kept in the terrarium.

Preparing and Maintaining a Desert Terrarium



A desert environment can be simulated in the classroom through the following procedures:

1. Locate a suitable glass container for use as a terrarium.
2. Wash the terrarium thoroughly with soap and water. Rinse it several times with clean, clear water and dry it.
3. Cover the bottom with four or five inches of fine, dry sand. Use red desert sand if it is available.
4. Plant cacti securely in the sand.
5. Add a desert animal such as a lizard or chameleon. Provide piles of rocks in which the animal can hide.
6. Place small cup of water, about the size of a soft drink bottle cap in the sand.
7. Cover the container with a screen top.
8. Sprinkle with water about every three weeks.
9. Provide water and appropriate food for the animal kept in the terrarium.

I. USABILITY

	Outstanding	Acceptable	Poor
1. Are format-printing and size of type suitable for your grade level?			
2. Is the size of the book appropriate?			
3. Is the cover attractive and durable?			
4. Is the book well-bound?			
5. Are the glossary, table of contents, index and bibliography satisfactory?			
6. Is the book suitable for the classroom teacher, non-specialist in science?			
7. Are the illustrations up-to-date with legends which are useful learning devices?			

II. AUTHORS

1. Are the authors authorities in the fields about which they are writing?			
2. Do the authors have experience and background in elementary science teaching?			
3. Is their philosophy in harmony with that of your school?			

III. CONTENT

1. Is the material up-to-date and related to the daily life of the child?			
2. Is the content of the book real science?			
3. Does the content develop concepts concerning the large areas of science?			
4. Is the historical development of science given some place?			
5. Is conservation adequately treated?			
6. Is the series well balanced between the physical and biological sciences?			
7. Does the content represent a continuous reorganization of past experience of the child?			
8. Are there sufficient and accurate charts, diagrammatic drawings, pictures, graphs and tables?			

IV. READABILITY

1. Is sentence length and space between lines conducive to easy reading?			
2. Is the vocabulary suitable to the children who will use the book?			
3. Is the reading level suitable to the concept development of the child?			
4. Is the style of writing clear and direct?			

V. ADAPTABILITY

	Outstanding	Acceptable	Poor
1. Is provision made for individual differences in children?			
2. Do the authors treat controversial subjects impartially?			
3. Is content significant to all children of any environment?			
4. Is the book organized so that units can be taught in any order or omitted entirely if necessary?			

VI. DEVELOPMENTAL METHODS

1. Are science concepts related to social applications?			
2. Is the child given opportunity for problem solving?			
3. Does the book provide opportunities for the child to learn by doing?			
4. Is the child's thinking guided through thought-provoking questions, suggestions and directions?			
5. Does the series feature a variety of teaching procedures?			
6. Are the problems and subject matter left open-ended?			
7. Is the inductive approach used whenever possible?			

VII. TEACHING AIDS

1. Are summaries, problems and questions at the end of the chapter adequate?			
2. Are references for teachers and students annotated?			
3. Is the teacher's manual more than an answer book?			
4. Is there an annotated, up-to-date film list?			
5. Is there a bibliography for teachers?			

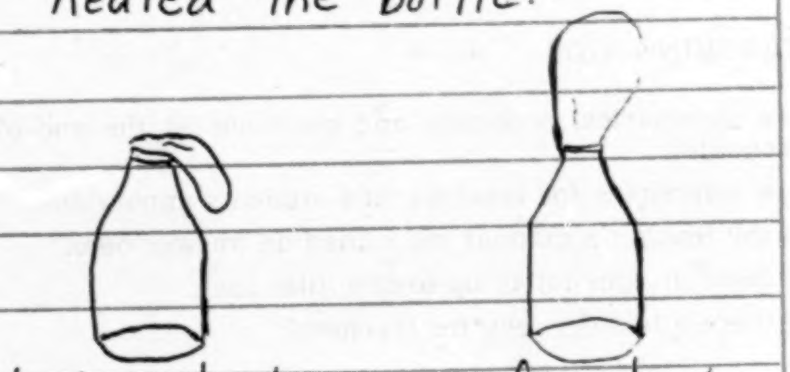
Air Experiment

Problem: What happens to air when it is heated?

Materials: Pyrex baby bottle, balloon, alcohol lamp.

What we did: We put the balloon over the bottle, and then we heated the bottle.

Diagram:



Result: The balloon grew larger when the bottle was heated.

Conclusion: The air in the bottle expands when it is heated.

APPENDIX A—PUBLISHERS OF SCIENCE TEXTS FOR ELEMENTARY SCHOOLS

Allyn and Bacon, Inc.
Rockleigh, New Jersey 07647

American Book Company
300 Pike Street
Cincinnati, Ohio 45202

Bobbs-Merrill Company
4300 W. 62nd Street
Indianapolis, Indiana 46206

Ginn and Company
450 W. Algonquin Rd.
Arlington Heights, Illinois 60005

Harcourt, Brace and World, Inc.
7555 Caldwell Avenue
Chicago, Illinois 60648

Harper and Row, Publishers, Inc.
2500 Crawford Avenue
Evanston, Illinois 60201

D. C. Heath and Company
2700 N. Richardt Avenue
Indianapolis, Indiana 46219

Holt, Rinehart and Winston, Inc.
383 Madison Avenue
New York, New York 10017

Laidlaw Brothers, Inc.
Thatcher and Madison
River Forest, Illinois 60305

Macmillan Company
434 S. Wabash Avenue
Chicago, Illinois 60605

McCormick-Mathers Publishing Co.
Wichita, Kansas 67201

McGraw-Hill Book Company, Inc.
330 W. 42nd Street
New York, New York 10036

Scott, Foresman and Company
1900 East Lake Avenue
Glenview, Illinois 60025

Silver Burdett Company
460 South Northwest Highway
Park Ridge, Illinois 60068

L. W. Singer Company
249 W. Erie Blvd.
Syracuse, New York 13201

APPENDIX B—SUPPLY HOUSES FOR SCIENCE EQUIPMENT AND SUPPLIES

Allied Electronics
100 N. Western Avenue
Chicago, Illinois 60680

Cambosco Scientific Company
342 Western Avenue
Boston, Massachusetts 02135

Carolina Biological Supply Co.
Burlington, North Carolina 27215

Central Scientific Company
2600 South Kostner Avenue
Chicago, Illinois 60623

Colborn School Supply
202 DeMers Avenue
Grand Forks, North Dakota 58201

Denoyer-Geppert Co.
5235-5259 Ravenswood Avenue
Chicago, Illinois 60640

Edmund Scientific Co.
Barrington, New Jersey 08007

General Biological Supply House (Turtox)
8200 South Hoyne Avenue
Chicago, Illinois 60620

Macalaster Scientific Corporation
Waltham Research & Development Park
186 Third Avenue
Waltham, Massachusetts 02154

Nasco
Ft. Atkinson, Wisconsin 53538

Northern School Supply and Equipment, Inc.
Fargo, North Dakota 58102

Nystrom and Co.
3333 Elston Avenue
Chicago, Illinois 60618

Office Machines & Furniture
A Division of Woodmansees, Inc.
225 Main Avenue
Bismarck, North Dakota 58501

Sargent-Welch Scientific Co.
7300 N. Linder Avenue
Skokie, Illinois 60076

Selective Educational Equipment, Inc.
Three Bridge Street
Newton, Massachusetts 02195

Stansi Scientific Company
1231 N. Honore Street
Chicago, Illinois 60622

Wards Natural Science Establishment, Inc.
P. O. Box 1712
Rochester, New York 14603

APPENDIX C—PUBLISHERS

Addison-Wesley Publishing Company, Inc.
3220 Porter Dr.
Palo Alto, Calif. 94304

Allyn and Bacon, Inc.
Rockleigh, New Jersey 07647

American Book Company
300 Pike Street
Cincinnati, Ohio 45202

American Guidance Service, Inc.
Publishers' Building,
Circle Pines, Minnesota 55014

American Technical Society
848 E. 58th Street,
Chicago, Ill. 60637

Benefic Press
1900 N. Narragansett,
Chicago, Ill. 60639

Chas. A. Bennett Co., Inc.
809 W. Detweiller Dr.,
Peoria, Ill. 61614

Bobbs-Merrill Company
4300 W. 62nd St.,
Indianapolis, Ind. 46206

Bruce Publishing Company
400 N. Broadway,
Milwaukee, Wis. 53201

Children's Press, Inc.
1224 W. Van Buren St.,
Chicago, Ill. 60607

Chilton Company
525 Locust St.,
Philadelphia, Pa. 19106

Clark Publishing Company
Box 205,
Pocatello, Idaho 83201

F. E. Compton and Company
Subsidiary of Encyclopedia Britannica

Conrad Publishing Company
Bismarck, North Dakota 58501

Doubleday and Company, Inc.
277 Park Avenue,
New York, N. Y. 10017

The Economy Company
Box 25308,
Oklahoma City, Oklahoma 73125

Encyclopedia Britannica
Educational Corporation
425 N. Michigan Avenue,
Chicago, Ill. 60611

Fideler Company
31 Ottawa N. W.,
Grand Rapids, Mich. 45902

Field Educational Publications, Inc.
609 Mission Street,
San Francisco, Calif. 94105

Field Enterprises, Inc.
510 Merchandise Mart Plaza,
Chicago, Ill. 60654

Follett Educational Corporation
1010 W. Washington Blvd.,
Chicago, Ill. 60607

W. H. Freeman and Company
660 Market Street,
San Francisco, Calif. 94104

Geographical Publishing Co.
20178 Parkside Dr.,
Rocky River, Ohio 44116

Ginn and Company
450 W. Algonquin Rd.,
Arlington Heights, Ill. 60005

Gregg Publishing Company
Division of McGraw-Hill Book Company

Grolier Society, Inc.
575 Lexington Avenue,
New York, N. Y. 10022

Harcourt, Brace and World, Inc.
7555 Caldwell Avenue,
Chicago, Ill. 60648

Harper and Row, Publishers, Inc.
2500 Crawford Avenue,
Evanston, Ill. 60201

Hayden Publishing Company
116 W. 14th Street,
New York, N. Y. 10011

D. C. Heath and Company
2700 N. Richardt Avenue,
Indianapolis, Ind. 46219

Holt, Rinehart and Winston, Inc.
383 Madison Avenue,
New York, N. Y. 10017

Houghton-Mifflin Company
1900 S. Batavia Avenue,
Geneva, Ill. 60134

Laidlaw Brothers, Inc.
Thatcher and Madison,
River Forest, Ill. 60305

Latin American Institute Press, Inc.
200 Park Avenue South,
New York, N. Y. 10003

J. B. Lippincott Company
East Washington Square,
Philadelphia, Pa. 19105

Barnell Loft Ltd.
111 S. Center Avenue,
Rockville Center, N. Y. 11572

Lyons and Carnahan
407 East 25th Street,
Chicago, Ill. 60616

McCormick-Mathers Publishing Company
Wichita, Kansas 67201

McGraw-Hill Book Company, Inc.
330 W. 42nd Street,
New York, N. Y. 10036

Macmillan Company
434 S. Wabash Avenue,
Chicago, Ill. 60605

Charles E. Merrill Books
1300 Alum Creek Dr.,
Columbus, Ohio 43216

North Dakota Studies
School Book Division
Box 228,
Bismarck, North Dakota 58501

Prentice-Hall, Inc.
Englewood Cliffs, N. J. 07632

Rand, McNally and Company
P. O. Box 7600
Chicago, Ill. 60680

John F. Rider, Publishers, Inc.
Division of Hayden Book Co.

William M. Sadlier, Inc.
15 Park Place,
New York City, N. Y. 10007

Stenoscript ABC Shorthand, Inc.
7817 Norfolk Avenue
Bethesda, Md. 20014

Science Research Associates
259 East Erie Street,
Chicago, Ill. 60611

Scott, Foresman and Company
1900 East Lake Avenue,
Glenview, Ill. 60025

Charles Scribner's Sons
597 Fifth Avenue,
New York, N. Y. 10017

Silver Burdett Company
460 South Northwest Highway,
Park Ridge, Ill. 60068

L. W. Singer Company
249 W. Erie Blvd.
Syracuse, N. Y. 13201

South-Western Publishing Co.
5101 Madison Road,
Cincinnati, Ohio 45227

The Open Court Publishing Co.
LaSalle, Illinois 61301

J. Weston Walch
1145 Congress Street,
Portland, Maine 04102

Franklin Watts
Division of Grolier Society

Webster Publishing
Division of McGraw-Hill Book Company

John Wiley and Sons
605 Third Avenue,
New York, N.Y. 10016

Zaner-Bloser Company
612 N. Park Street,
Columbus, Ohio 43215

APPENDIX D—EDUCATIONAL MEDIA

Instructional Media

The process of science education depends heavily on the resources and services that are available from the media program and its staff. The availability of many materials in a variety of formats makes it necessary to select carefully. Before this can be done, one must first learn what is currently available, and since there is as yet no national system of bibliographical control of information about the newer educational media as there is for print material, the selection process must be carried on by consulting a variety of indexes, catalogs, and reviewing services.

Selection tools for media personnel include annotated lists of recommended reference materials in all major subject areas, including science. For optimum results, a variety of media should be provided in both print and nonprint form.

The list of guides included here should be helpful in the selection and evaluation of multi-media materials for supplementary use in elementary science classes.

Allison, Mary L., ed. **NEW EDUCATIONAL MATERIALS.** New York: Citation Press, 1967.

Deason, Hilary J., comp. **AAAS SCIENCE BOOK LIST FOR CHILDREN.** Washington, D. C.: American Association for the Advancement of Science, 1963.

Gaver, Mary V., ed. **THE ELEMENTARY SCHOOL LIBRARY COLLECTION, PHASES 1-2-3,** Revised annually. Newark, N. J.: The Bro-Dart Foundation. (Includes books, periodicals, professional materials, and audiovisual materials.)

Hodges, Elizabeth D., ed. **BOOKS FOR ELEMENTARY SCHOOL LIBRARIES.** Chicago: American Library Association, 1969.

National Information Center for Educational Media. **INDEX TO 16 MM. EDUCATIONAL FILMS.** Glenn McMurry, director. New York: McGraw-Hill, 1967.

INDEX TO 35 MM. EDUCATIONAL FILMSTRIPS. Glenn McMurry, director. New York: McGraw-Hill, 1968.

Rufsvold, Margaret I., and Guss, Carolyn, **GUIDES TO NEWER EDUCATIONAL MEDIA,** 2nd ed. Chicago: American Library Association, 1967.

SCIENCE BOOKS, a quarterly review. Washington, D. C.: American Association for the Advancement of Science.

Scott, Marion H. **PERIODICALS FOR SCHOOL LIBRARIES.** Chicago: American Library Association, 1969.

Shor, Rachel, and Fidell, Estelle A., eds. **CHILDREN'S CATALOG,** 11th ed. New York: The H. W. Wilson Company, 1966.

STANDARDS FOR SCHOOL MEDIA PROGRAMS. Published by the American Library Association, Chicago, Illinois, and the National Education Association, Washington, D. C., 1969.

APPENDIX E—PERIODICALS

AAAS—QUARTERLY REPORT, American Association for the Advancement of Science, 1515 Massachusetts Ave., N.W., Washington, D. C. 20005, $6.50 per year. Reviews textbooks and reference works in applied sciences in elementary grades, in secondary school, colleges and professional books useful for reference by student and teachers.

CORNELL SCIENCE LEAFLET, New York State College of Agriculture at Cornell University, Ithaca, New York 14850, three issues per year, $1.00.

GRADE TEACHER, Teachers Publishing Corporation, Darien, Connecticut, $6.00 (9 issues) per year.

THE INSTRUCTOR, F. A. Owen Publishing Co., 7 Bank Street, Dansville, New York 14437, $7.00.

***NATURE AND SCIENCE,** American Museum of Natural History, Natural History Press, A division of Doubleday & Co., Inc., Garden City, New York, $3.50 (18 issues) per year.

***RANGER RICK'S NATURE MAGAZINE,** National Wildlife Federation, Inc., 1412 Sixteenth Street, N.W., Washington, D. C. 20036, $6.00 (10 issues) per year.

SCIENCE AND CHILDREN, National Science Teachers Association, 1201 Sixteenth Street, Washington, D. C. 20036, $5.00 (8 issues) per year.

***WEEKLY READER,** American Education Publications, 1250 Fairwood Ave., Columbus, Ohio.

*For students

APPENDIX F—U. S. MANNED SPACE FLIGHTS

	DATE	FLIGHT TIME (Hrs: Min: Sec:)	REVO-LUTIONS	SPACECRAFT NAME	REMARKS
Project Mercury					
Alan B. Shepard, Jr.	5/5/61	00:15:22	Sub-orbital	Freedom 7	America's first manned space flight.
Virgil I. Grissom	7/21/61	00:15:37	Sub-orbital	Liberty Bell 7	Evaluated spacecraft functions.
John H. Glenn, Jr.	2/20/62	04:55:23	3	Friendship 7	America's first manned orbital space flight.
M. Scott Carpenter	5/24/62	04:56:05	3	Aurora 7	Initiated research experiments to further future space efforts.
Walter M. Schirra, Jr.	10/3/62	09:13:11	6	Sigma 7	Developed techniques and procedures applicable to extended time in space.
L. Gordon Cooper, Jr.	5/15-16/63	34:19:49	22	Faith 7	Met the final objective of the Mercury program—spending one day in space.
Project Gemini					
Virgil I. Grissom John W. Young	3/23/65	04:52:31	3	Gemini-III	America's first two-man space flight.
James A. McDivitt Edward H. White, II	6/3-7/67	97:56:12	62	Gemini-IV	First "walk in space" by an American astronaut. First extensive maneuver of spacecraft by pilot.
L. Gordon Cooper, Jr. Charles Conrad, Jr.	8/21-29/65	190:55:14	120	Gemini-V	Eight day flight proved man's capacity for sustained functioning in space environment.
Frank Borman James A. Lovell, Jr.	12/4-18/65	330:35:01	206	Gemini-VII	World's longest manned orbital flight.
Walter M. Schirra, Jr. Thomas P. Stafford	12/15-16/65	25:51:24	16	Gemini-VI-A	World's first successful space rendezvous.
Neil A. Armstrong David R. Scott	3/16-17/66	10:41:26	6.5	Gemini-VIII	First docking of two vehicles in space.
Thomas P. Stafford Eugene A. Cernan	6/3-6/66	72:20:50	45	Gemini-IX-A	Three rendezvous of a spacecraft and a target vehicle. Extra-vehicular exercise—2 hours, 7 minutes.
John W. Young Michael Collins	7/18-21/66	70:46:39	43	Gemini-X	First use of target vehicle as source of propellant power after docking. New altitude record—475 miles.
Charles Conrad, Jr. Richard F. Gordon, Jr.	9/12-15/66	71:17:08	44	Gemini-XI	First rendezvous and docking in initial orbit. First multiple docking in space. First formation flight of two space vehicles joined by a tether. Highest manned orbit—apogee about 853 miles.
James A. Lovell, Jr. Edwin E. Aldrin, Jr.	11/11-15/66	94:34:31	59	Gemini-XII	Astronaut walked and worked outside of orbiting spacecraft for more than 5½ hours—a record proving that a properly equipped and prepared man can function effectively outside of his space vehicle. First photograph of a solar eclipse from space.

	DATE	FLIGHT TIME (Hrs: Min: Sec:)	REVO-LUTIONS	SPACECRAFT NAME	REMARKS
Project Apollo					
Walter M. Schirra, Jr. Donn F. Eisele Walter Cunningham	10/11-22/68	260:8	163	Apollo 7	Live T.V. from space. Rendezvoused with discarded Saturn 4B booster.
William O. Anders Frank Borman James A. Lovell	12/21-27/68	147 hours 590,000 mi.	around the moon	Apollo 8	First time that man has broken his bonds to the earth, made 10 orbits of the moon, and returned to the earth. Pictures of the moon from 70 miles above the moon, pictures of the earth from the moon and television from space were spectacular. A very exciting adventure for all earth people in this generation.
James McDivitt Russell Schweickart David Scott	3/3-13/69			Apollo 9	The main purpose was to test the Lunar Module (LM), code-named Spider. The Lunar Module was carried aloft, separated from the Command Module, guided in space by McDivitt and Schweickart, up to 111 miles from mother ship, and successfully linked up again with the Command Module. This Lunar Module will eventually land astronauts on the moon.
Eugene A. Cernan Thomas P. Stafford John W. Young	5/18-26/69	8 days, 8 min. ¾ million miles	31 orbits of the moon	Apollo 10	This trip to the moon carried a color TV camera which sent back to the earth spectacular live color TV pictures. Two astronauts tested the lunar module by descending to within 50,000 feet of the moon's surface.
Neil A. Armstrong Edwin E. Aldrin, Jr. Michael Collins	7/16-24/69	8 days, 3 hrs. 19 min.	Footprints on the Moon Lunar Module was on moon's surface for 21 hrs., 36 min. Moon walk lasted for 2 hrs., 11 min.	Apollo 11	Armstrong touched his foot on the moon on Sunday, July 20, at 10:56:20 p. m. EDT. Twenty minutes later Aldrin joined him. Live television pictures were broadcast to the earth as millions of people watched. The astronauts collected samples of moon dust and rocks. They were quarantined in a special laboratory for 18 days after splashdown to make sure that they didn't bring back any strange organisms from the moon. No harmful effects were noticed by the astronauts or laboratory animals during quarantine.

APPENDIX G—PROFESSIONAL REFERENCES IN ELEMENTARY SCHOOL SCIENCE EDUCATION

References that contain information which is helpful in planning and implementing an elementary school science program.

Association for Childhood Education International. **YOUNG CHILDREN AND SCIENCE,** Washington, D. C., 1964. 56 pp.

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APPENDIX H—ENGLISH METRIC CONVERSION TABLE

1 inch = 25.4 millimeters
1 inch = 2.54 centimeters
1 inch = 0.0254 meters
1 foot = 30.48 centimeters
1 foot = 0.3048 meters
1 yard = 0.9144 meters
1 mile = 1609.347 meters
1 mile = 1.609347 kilometers
1 ounce = 28.3495 grams
1 pound = 453.59 grams
1 pound = 0.45359 kilograms
1 ton = 907.185 kilograms
1 ounce fluid = 29.57 millimeters
1 pint = 474. milliliters
1 quart = 946.1 milliliters
1 ounce fluid = 0.02957 liters
1 quart = 0.9461 liters
1 gallon = 3.785 liters
1 sq. inch = 6.452 cm^2
1 sq. foot = 0.0929 m^2
1 cu. inch = 16.387 cm^3
1 cu. foot = 0.02832 m^3

1 millimeter = 0.03937 inches
1 centimeter = 0.3937 inches
1 meter = 39.37 inches
1 centimeter = 0.03281 feet
1 meter = 3.281 feet
1 meter = 1.094 yard
1 kilometer = 3281 feet
1 kilometer = 0.62137 miles
1 gram = 0.03527 ounces
1 gram = 0.002205 pounds
1 kilogram = 2.2046 pounds
1 kilogram = 0.0011 ton
1 milliliter = .03344 ounces
1 milliliter = 0.00211 pint
1 milliliter = 0.001057 quarts
1 liter = 33.82 ounces
1 liter = 1.057 quarts
1 liter = .2639 gallons
1 cm^2 = 0.155 sq. inch
1 m^2 = 10.76 sq. feet
1 ml = .061 cu. inch
1 m^3 = 35.32 cu. feet

APPENDIX I—TEMPERATURE CONVERSION TABLE

F	C	F	C	F	C	F	C
—40 =	—40.0	41 =	5.00	66 =	18.9	91 =	32.8
—35 =	—37.2	42 =	5.56	67 =	19.4	92 =	33.3
—30 =	—34.4	43 =	6.11	68 =	20.0	93 =	33.9
—25 =	—31.7	44 =	6.67	69 =	20.6	94 =	34.4
—20 =	—28.9	45 =	7.22	70 =	21.1	95 =	35.0
—15 =	—26.1	46 =	7.78	71 =	21.7	96 =	35.6
—10 =	—23.3	47 =	8.33	72 =	22.2	97 =	36.1
— 5 =	—20.6	48 =	8.89	73 =	22.8	98 =	36.7
0 =	—17.8	49 =	9.44	74 =	23.3	99 =	37.2
5 =	—15.0	50 =	10.0	75 =	23.9	100 =	37.8
10 =	—12.2	51 =	10.6	76 =	24.4	110 =	43
15 =	—9.44	52 =	11.1	77 =	25.0	120 =	49
20 =	—6.67	53 =	11.7	78 =	25.6	130 =	54
25 =	—3.89	54 =	12.2	79 =	26.1	140 =	60
30 =	—1.11	55 =	12.8	80 =	26.7	150 =	66
31 =	—0.56	56 =	13.3	81 =	27.2	160 =	71
32 =	0	57 =	13.9	82 =	27.8	170 =	77
33 =	0.56	58 =	14.4	83 =	28.3	180 =	82
34 =	1.11	59 =	15.0	84 =	28.9	190 =	88
35 =	1.67	60 =	15.6	85 =	29.4	200 =	93
36 =	2.22	61 =	16.1	86 =	30.0	210 =	99
37 =	2.78	62 =	16.7	87 =	30.6	212 =	100
38 =	3.33	63 =	17.2	88 =	31.1	220 =	104
39 =	3.89	64 =	17.8	89 =	31.7	230 =	110
40 =	4.44	65 =	18.3	90 =	32.2	240 =	116

APPENDIX J—RELATIVE HUMIDITY

Temp of Dry Bulb	Difference in degrees between Dry Bulb and Wet Bulb (Fahrenheit)																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
98	96	93	89	86	82	79	76	72	69	66	63	60	57	54	52	49	46	44	41
96	96	93	89	85	82	78	75	72	68	65	62	59	57	54	51	48	45	43	40
94	96	93	89	85	81	78	75	71	68	65	62	59	56	53	50	47	44	42	39
92	96	92	88	85	81	78	74	71	67	64	61	58	55	52	49	46	43	40	38
90	96	92	88	84	81	77	74	70	67	63	60	57	54	51	48	45	42	39	36
88	96	92	88	84	80	77	73	69	66	63	59	56	53	50	47	44	41	38	35
86	96	92	88	84	80	76	72	69	65	62	58	55	52	49	45	42	39	36	33
84	96	92	87	83	79	76	72	68	64	61	57	54	51	47	44	41	38	35	32
82	96	91	87	83	79	75	71	67	64	60	56	53	49	46	43	40	36	33	30
80	96	91	87	83	79	74	70	66	63	59	55	52	48	45	41	38	35	31	28
78	95	91	86	82	78	74	70	66	62	58	54	50	47	43	40	36	33	30	26
76	95	91	86	82	78	73	69	65	61	57	53	49	45	42	38	34	31	28	24
74	95	90	86	81	77	72	68	64	60	56	52	48	44	40	36	33	29	26	22
72	95	90	85	80	76	71	67	63	58	54	50	46	42	38	34	31	27	23	20
70	95	90	85	80	75	71	66	62	57	53	49	44	40	36	32	28	24	21	17
68	95	90	84	79	75	70	65	60	56	51	47	43	38	34	30	26	22	18	15
66	95	89	84	78	74	69	64	59	54	50	45	41	36	32	28	23	20	16	12
64	94	89	83	78	73	68	63	58	53	48	43	39	34	30	25	21	17	13	9
62	94	88	83	77	72	67	61	56	51	46	41	37	32	27	23	18	14	10	5
60	94	88	82	77	71	65	60	55	50	44	39	34	29	25	20	15	11	6	2
58	94	88	82	76	70	64	59	53	48	42	37	31	26	22	17	12	7	2	
56	94	87	81	75	69	63	57	51	46	40	35	29	24	19	13	8	3		
54	93	87	80	74	68	61	55	49	43	38	32	26	21	15	10	5			
52	93	86	79	73	66	60	54	47	41	35	29	23	17	12	6				
50	93	86	79	72	65	59	52	45	38	32	26	20	14	8	2				
48	92	85	77	70	63	56	49	42	36	29	22	16	10	4					
46	92	84	77	69	62	54	47	40	33	26	19	12	6						
44	92	84	75	68	60	52	45	37	29	22	15	8							
42	91	83	74	66	58	50	42	34	26	18									
40	91	82	73	65	56	47	39	30	26										
38	91	82	72	64	56	46	38												
36	90	80	71	62	54	46													
34	89	79	69	62	54														
32	89	78	68	61	48														
30	88	76	66	56	47														
28	87	75	65	53	43														
26	86	73	63	50	38														
24	85	71	60	47															
23	85	70	58																
22	85	69																	
21	85																		

APPENDIX K—SUGGESTED SCIENCE SEQUENCES

ORGANIZATION OF ELEMENTARY SCHOOL SCIENCE

	I. LIVING THINGS	II. GROWING BODIES	III. AIR, WATER, AND WEATHER
KINDERGARTEN	1. All things are either living or nonliving. 2. Living things can be plant or animal. 3. There are many kinds of plants and animals. 4. Plants and animals need food, air, and water to live. 5. Green plants need light to grow.	1. All living things grow. 2. All living things are not the same size. 3. We cannot tell how big we will become. 4. For growth, we need certain basic things, such as water, food, light, air, and exercise.	1. Air is all around us. 2. We can feel air but we cannot see it. 3. We can see what air does. 4. Moving air is called wind. 5. Air can warm us or cool us.
GRADE 1	1. Most animals can move from place to place. 2. Animals move in different ways. 3. Animals live in many kinds of places. 4. There are many kinds of plants. 5. Most plants cannot move about as animals do. 6. Certain conditions (temperature, water, etc.) are necessary for living things.	1. Certain kinds of food are necessary for growth. 2. Some foods are better for us than others. 3. Food alone does not determine how we grow. 4. We need more of some kinds of food than others.	1. Air takes up space. 2. Most containers which we say are empty are really filled with air. 3. The surface of the earth is warmed in the daytime and cooled at night. This in turn warms or cools the air above it. 4. Winds move at different speeds and from different directions. 5. Winds can carry plant seeds. 6. Winds help things to dry. 7. Winds are sometimes harmful. 8. Rain and snow come from water vapor (clouds) in the air. 9. Clouds have different shapes.
GRADE 2	1. Some animals eat plants. 2. Some animals hunt other animals for food. 3. Green plants make their own food. 4. Green plants store food in their roots, stems, leaves, bulbs, and seeds. 5. Some animals move from place to place with the seasons in order to find food. 6. Living things change as they grow.	1. Teeth decay because of acids produced in the mouth by bacterial action on food. 2. Sweet, sticky food is more harmful to our teeth than coarse, crisp food. 3. We can protect our teeth by brushing after we eat. 4. Even with good personal care we need to have our teeth looked at regularly by the dentist.	1. Fire needs air to burn. 2. Plants and animals generally need air to live. 3. A thermometer measures temperature. 4. Temperature is a measure of "hotness." 5. A cloud is made of water droplets or tiny ice crystals. 6. Weather affects our work and play. 7. Water evaporates from puddles, lakes, and oceans to go into the air again.
GRADE 3	1. Plants and animals depend on other living things for their well-being. 2. Many plants and animals are adapted to living in certain kinds of places. 3. Many animals have special adaptations which protect them from their enemies. 4. Man depends on other living things for his food, clothing, and shelter. 5. Man should exercise good conservation practices so as not to disrupt the interdependence of living things.	1. Sleep is essential to life. 2. Rest before fatigue is considered better than rest following fatigue. 3. Sleep comes easily in the proper atmosphere. 4. Lack of sleep affects us emotionally as well as physically. 5. The art of relaxation can be learned, and relaxation helps us to avoid fatigue.	1. Air is a real substance and occupies space. 2. Air expands when heated. 3. Cooled air contracts and moves downward. 4. Heated air is moved upwards. 5. Wind is moving air. 6. Local winds are caused by unequal heating of the earth's surface. 7. Wind direction is indicated by a wind vane.
GRADE 4	1. Living things (plants) are produced by similar living things. 2. Some plants grow from seeds. 3. Seeds are produced by flowers. 4. Fruit develops from the flower. 5. Seeds are distributed by explosion, wind, water, and animals. 6. Some plants produce bulbs or tubers while lower plants such as molds, fungi, and ferns reproduce by spores. 7. New plants can be grown from leaves or stems of other plants. 8. Living things (animals) are produced by similar living things. 9. Many animals lay eggs, others bear living young. 10. Some animals feed and protect their growing young. 11. Some animals produce many young at a time. 12. Some simple (microscopic) animals reproduce by breaking apart.	1. Digestion is the process of breaking food down into smaller chemical parts so it can be used by the body. 2. Only complete digestion of food can give us the full benefits of what we eat. 3. The undigestible portion of food (cellulose) is necessary for the normal functioning of intestines. 4. Different parts of the digestive tract have quite different functions in the total process. 5. We are able to eat what we wish rather than choose foods of the same type because the entire digestive system functions whenever we eat. 6. Activity and emotions may have an adverse effect on digestion.	1. Water evaporates into invisible vapor. 2. When water vapor cools, it condenses into liquid. 3. Condensed water vapor falling to the ground is called precipitation. 4. Rain, snow, sleet, and hail are all forms of precipitation. 5. Some precipitation soaks into the ground while some runs off into streams, lakes, and oceans. 6. Excessive precipitation causes great damage by erosion and flood. 7. The process of continuous evaporation and condensation is called the water cycle.
GRADE 5	1. Animals require oxygen from the air, and they give off carbon dioxide. 2. Animals digest their food so that it can be absorbed and circulated to all parts of their bodies. 3. Animals are composed of cells. 4. The cells use food and oxygen to produce energy for growth and movement. 5. There are many different kinds of animal cells; nerve, muscle, blood, bone, and skin are the most common. 6. The smallest animals are composed of a single cell, while larger animals are composed of millions of cells. 7. Plants are composed of cells. 8. Green plants can produce their own food by the process of photosynthesis. 9. Green plants combine carbon dioxide with water to produce their food (sugar). 10. Sunlight provides the energy for the process of photosynthesis. 11. Green plants are the first link in any food chain.	1. A wound is any break in the skin. 2. The body has ways of controlling bleeding, but often it is best if we assist. 3. Bacteria are all around us and they can enter the body through any break in the skin. Cleanliness is very necessary to avoid infection in a wound. 4. Even a clean cloth may have bacteria on it. We should cover cuts with sterile cloth if possible. This allows no dirt or bacteria to enter the body. 5. Whenever a blood vessel is cut, bleeding will occur. The amount of bleeding depends on the number and size of the vessels cut.	1. Air is a mixture of oxygen and other gases. 2. Air takes up space and has weight. 3. Air exerts pressure. 4. A barometer measures air pressure. 5. Pressure in moving air is less than pressure in still air. 6. Air heats when it is compressed and cools when it expands. 7. The air surrounding the earth is called the atmosphere. 8. The three layers of the atmosphere are the troposphere, the stratosphere, and the ionosphere.
GRADE 6	1. Scientists have arranged plants and animals into similar groups in order to study them. 2. Classification of living things is based on their structure. 3. Classification emphasizes the development of simple forms of life into more complex forms. 4. Living things have developed into complex organisms very slowly during millions of years. 5. Many different kinds of plants and animals live together in nature and depend on each other for food.	1. To achieve physical fitness there is a need for strenuous physical activity. 2. Physical fitness helps us do most everything we try easier and better than when we are not physically fit. 3. Food, rest, and sleep are important helps in achieving physical fitness. 4. Physical fitness ultimately depends on how strong the heart muscle is because we depend on it for oxygen and food in the cells and for taking away waste products. 5. Increase in strength of all muscles, including the heart, depends on exercise.	1. The conditions of the atmosphere are measured by various weather instruments. 2. Atmospheric conditions vary from place to place and from time to time. 3. Low pressure areas are generally associated with stormy weather and high pressure areas are generally associated with fair weather. 4. The general movement of our daily weather across the country is from west to east. 5. The Weather Bureau predicts the weather from the measured conditions of the atmopshere. 6. The weather map shows the daily conditions of our atmosphere.

(WITH SUGGESTED GRADE PLACEMENTS)

IV. THE EARTH AND ITS COMPOSITION	V. THE SOLAR SYSTEM AND BEYOND	VI. MATTER AND ENERGY
1. Rocks are hard, nonliving things. 2. Rocks have various colors, sizes, and shapes. 3. Gravel and pebblgs are small pieces of rock. 4. Some rocks feel rough and others feel smooth. 5. There are many kinds of rocks.	1. We live on the earth. 2. The earth is very large. 3. The sun gives us light and heat. 4. Light reflected from the moon helps us see at night.	1. Sounds are made by people, and animals, and moving objects. 2. Sounds travel in all directions. 3. We hear sounds with our ears. 4. Sounds may be pleasant or unpleasant. 5. Sounds can warn us of danger.
1. The land on which we live is made up of rock and soil. 2. Sand is broken bits of rock. 3. Soil is made of broken-down rock and decayed plant and animal material. 4. Stone is used as a building material. 5. Stone which is used to build things is strong and hard. 6. Stone is used in many ways around the house and in schools.	1. The earth is round. 2. There is air all around the earth. 3. The sun is much larger than the earth. 4. The four seasons of the earth are spring, summer, fall, and winter. 5. The moon is smaller than the earth. 6. Sometimes we see both the moon and the sun in the sky.	1. Light lets us see. 2. Shadows are made when light is blocked. 3. The sun, fire, and electric lamps produce light and heat. 4. Heat has many uses. 5. Fire may cause great damage.
1. Rocks are constantly being worn down or broken by wind, water, temperature changes, plants, and chemicals. 2. Different kinds of soil are formed from different kinds of rock. 3. Soil contains bits of broken rock and decaying plant and animal matter. 4. Most plants need soil which contains organic matter. 5. Soils differ in their ability to hold water. 6. Topsoil is a valuable resource and should be conserved.	1. The earth revolves around the sun. 2. The earth revolves around the sun once in our year. 3. The rotation of the earth causes day and night. 4. The change of seasons affects man, animals, and plants. 5. We can tell direction by the sun and stars. 6. The sun rises in the east and sets in the west. 7. The sun and stars are always shining. 8. The moon is the earth's nearest natural neighbor. 9. Stars vary in size, brightness, and in distance from us. 10. Stars look small because they are so far away.	1. Our world is made of many different kinds of matter (material). 2. Matter may be solid, liquid, or gas. 3. Solids have a definite volume and shape. 4. Liquids have a definite volume but take the shape of their containers. 5. Gases have no definite volume or shape. 6. Many materials are enough alike to be grouped into "families" such as metals, plastics, etc.
1. The surface of the earth is constantly changing. 2. Rocks can be broken apart by heat (sun), freezing, water, and plants. 3. Mountains and hills are being worn down. 4. Running water is largely responsible for the wearing-down process (erosion). 5. Earthquakes, volcanoes, and slower earth movements are constantly building up new mountains.	1. The sun is the center of our solar system. 2. The sun is composed of hot glowing gases. 3. There are nine known planets in the solar system. 4. The earth is one of these nine planets. 5. The nearly circular paths of the planets around the sun are called orbits. 6. The moon and planets shine only by reflected light. 7. The same side of the moon always faces the earth. 8. The apparent shape of the moon depends on the position of its sunlit surface that we can see. 9. There is no air or water on the moon.	1. Magnets attract things made of iron. 2. Magnets are strongest at their ends or poles. 3. Magnetic force can act through some materials. 4. Magnets repel as well as attract each other. 5. A compass can be used to determine direction. 6. A compass is a magnet which can turn easily.
1. Rocks are grouped as igneous, sedimentary, and metamorphic. 2. Igneous rocks form when magna or lava cools. 3. Sedimentary rocks are formed when sand or other sediment is compressed and converted into rock. 4. Metamorphic rocks are formed from other rocks which have been heated or squeezed into new forms. 5. Rocks are composed of minerals. 6. Three common rock-forming minerals are quartz, feldspar, and mica. 7. Fossils are evidence of life in the past and may be found in sedimentary rock. 8. A geologist is a scientist who studies the history of the earth and the rocks and minerals which make up the earth's surface..	1. Our temperature zones are caused by the tilt of the earth's axis. 2. The seasons are caused by the tilt of our axis and the position of the earth in its orbit. 3. The sun is an average-size star. 4. The planets shine by reflected sunlight. 5. The planets vary in size and distance from the sun. 6. The planets and their satellites are held in their orbits by gravity and inertia. 7. The moon rises at a different time each day. 8. The tides are caused by the gravitational pull of the sun and the moon.	1. Heat is a form of energy. 2. Heat energy is used to run many machines. 3. Heat is produced by fire, friction, and electricity. 4. Metals are good conductors of heat; wood is a poor heat conductor. 5. Heat from friction is wasted energy. 6. Friction makes it difficult to slide one object along another. 7. Friction is reduced by the use of bearings and lubrication. 8. Friction is useful in stopping moving things. 9. Machines are used to make work easier.
1. The interior of the earth is hot. 2. Geysers and hot springs bring dissolved minerals to the earth's surface. 3. Volcanoes, earthquakes, and geysers are earth-building forces. 4. Weathering and erosion wear down the surface of the earth. 5. Water, wind, chemical reactions, temperature changes, and plant growth slowly disintegrate rock. 6. Disintegrated rock is moved to lower areas by water, ice, and wind. 7. Topsoil is often lost faster than it is replaced. 8. Topsoil contains sand, silt, clay, and humus. 9. Soil conservation practices include crop rotation, terracing, and contour farming. 10. The ocean has been made salty by the dissolved minerals that streams have carried into it. 11. Limestone caves are formed by action of water as it seeps down through rocks. 12. The depletion of resources, including soil, changes the way we live.	1. The solar system is composed of the sun, planets, satellites, planetoids, meteors, and comets. 2. There are various theories describing the origin of our solar system and the universe. 3. The sun is a sphere of hot gases. 4. Disturbances (storms) on the sun's surface are called sunspots. 5. The volume of the sun is about 1 million times the the volume of the earth. 6. The planets rotate as they revolve. 7. Our sun is an average-size star. 8. Galaxies are huge collections of stars. Our galaxy is called the Milky Way. 9. The stars in our sky seem to revolve around the earth because of the earth's rotation. 10. Constellations are groups of stars which appear to outline a figure. 11. Different constellations come into view with the change in seasons.	1. Static electricity can be produced by friction. 2. Electricity can be generated by moving wires through a magnetic field of force. 3. Electricity from the generating plant comes into our homes through wires. 4. We change electrical energy into heat, light, magnetism, and sound for our use. 5. A switch is used to start and stop the flow of electricity in a circuit. 6. Some materials are electrical conductors and some are electrical insulators. 7. Fuses and circuit breakers protect our homes from electrical accidents.
1. Rocks are mixtures of minerals. 2. Minerals are naturally occurring inorganic substances and have a definite chemical composition. 3. Minerals have definite physical properties. 4. Minerals may be identified by color, hardness, and other characteristics. 5. Minerals that can be mined profitably are usually called ores. 6. Minerals are nonrenewable resources and should be used wisely.	1. Planets differ in physical characteristics such as size, motion, gravity, atmosphere, and temperature. 2. Forces man must consider when sending rockets into space are gravity, inertia, and friction. 3. Energy released from the sun is called solar radiation. 4. When the moon blocks the sunlight from the earth, a solar eclipse occurs. 5. When the earth blocks the sunlight from the moon, a lunar eclipse occurs. 6. The phases of the moon result from our viewing various amounts of the lighted side of the moon. 7. Our units of time are based on astronomical motions. 8. Astronomers use telescopes, spectroscopes, and cameras in their observations. 9. The great distances through space are often measured in light years. 10. Our knowledge of astronomy has developed as the result of the work of many scientists over many years. This knowledge is incomplete and always subject to questioning and change.	1. Matter is composed of very small particles called atoms. 2. Groups of atoms join together to form molecules. 3. A substance composed of only one kind of atom is called an element. 4. There are over 100 known elements. 5. Elements can combine to form compounds. 6. Chemical changes result in the formation of new substances. 7. The combustion of fuel is a chemical change which releases energy. 8. Physical changes do not result in the formation of new substances. 9. Matter may be solid, liquid, or gas depending on the behavior of its molecules. 10. Some atoms are radioactive and release energy. 11. Man ha[illegible]ed to use the energy released from radioactiv[illegible]ials, which is called nuclear energy.